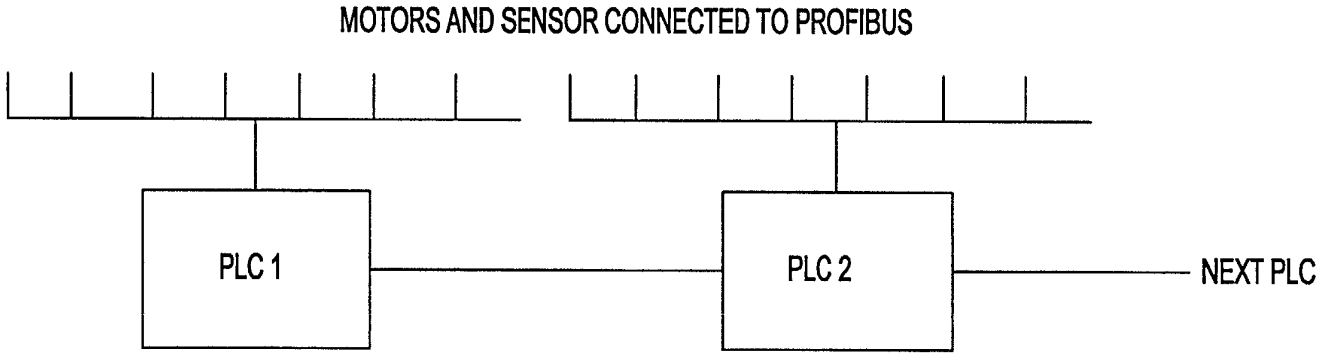



FIG. 1

(PRIOR ART)

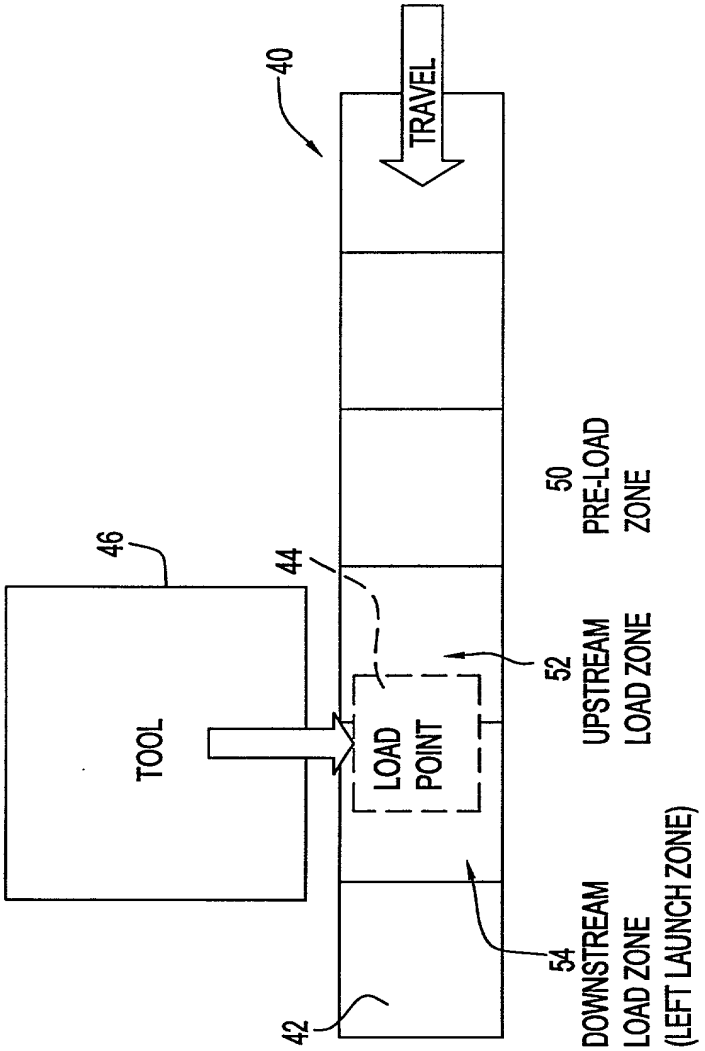

40
TRAVEL
46
44
TOOL
LOAD
POINT
50
PRE-LOAD
ZONE
52
UPSTREAM
LOAD ZONE
54
DOWNSTREAM
LOAD ZONE
(LEFT LAUNCH ZONE)
42
LOAD AREA
48

FIG. 2A

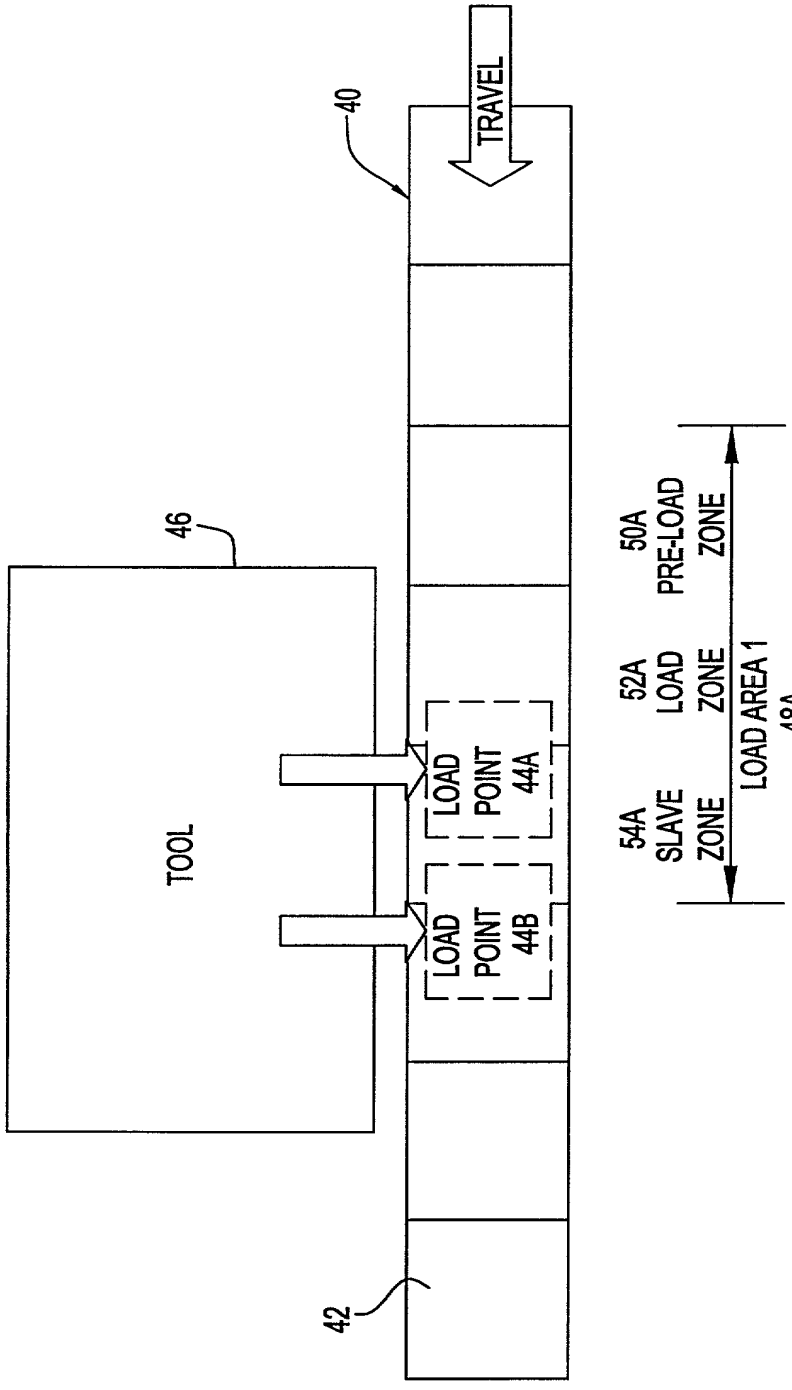

TRAVEL
40
46
TOOL
LOAD POINT 44A
LOAD POINT 44B
42
50A PRE-LOAD ZONE
52A LOAD ZONE
54A SLAVE ZONE
LOAD AREA 1 48A
50B PRE-LOAD ZONE
52B LOAD ZONE
54B SLAVE ZONE
LOAD AREA 2 48B

FIG. 2B

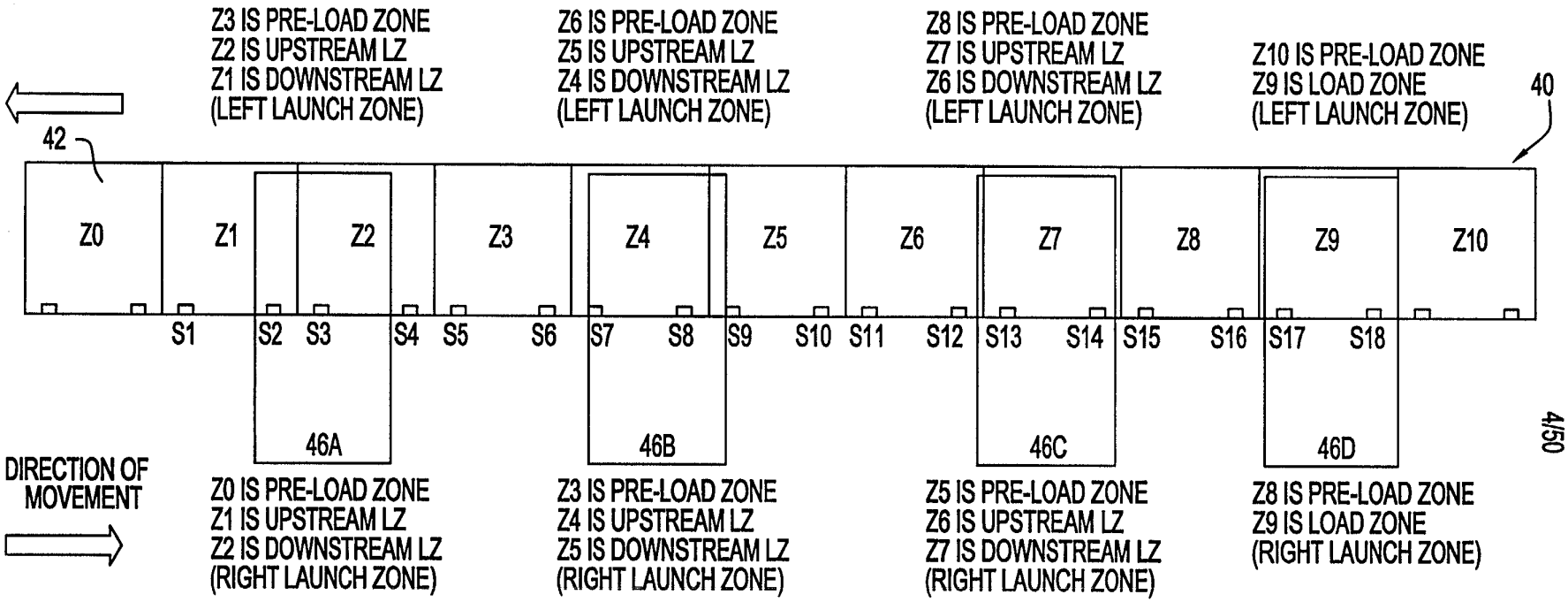



FIG. 2C

NEIGHBORHOOD FOR A RAIL ZONE

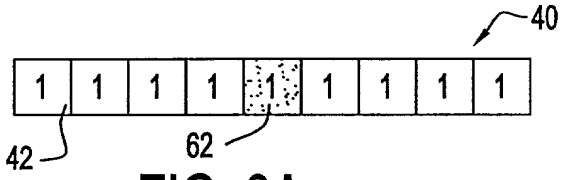
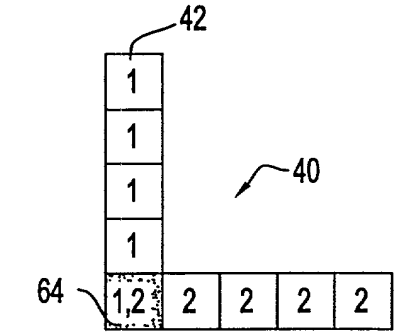



FIG. 3A




NEIGHBORHOODS FOR A CORNER

FIG. 3B

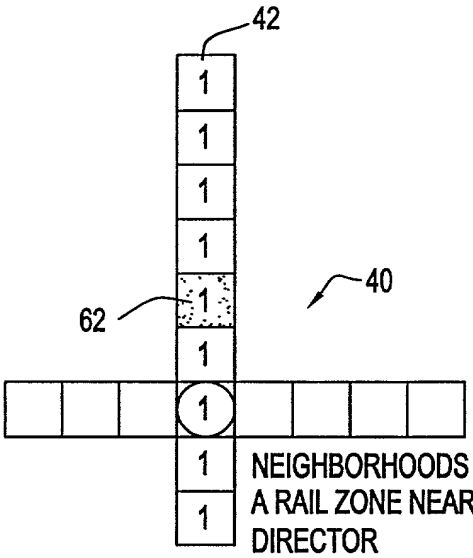



FIG. 3C

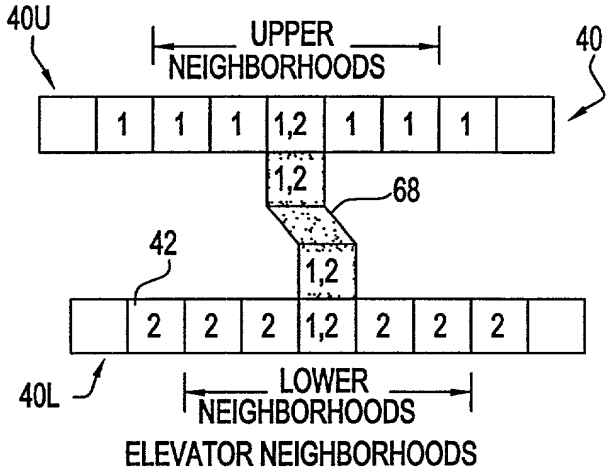



FIG. 3D

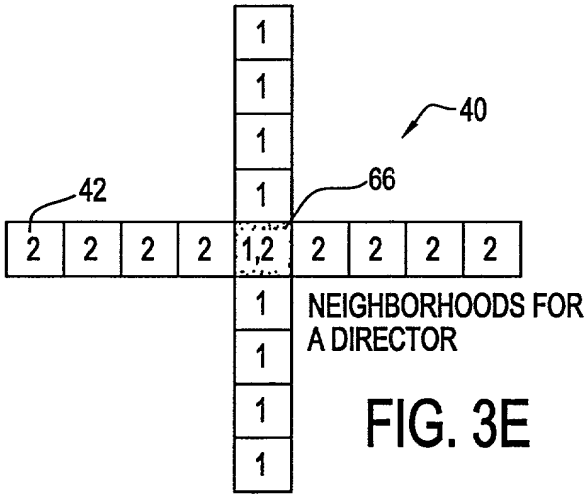



FIG. 3E

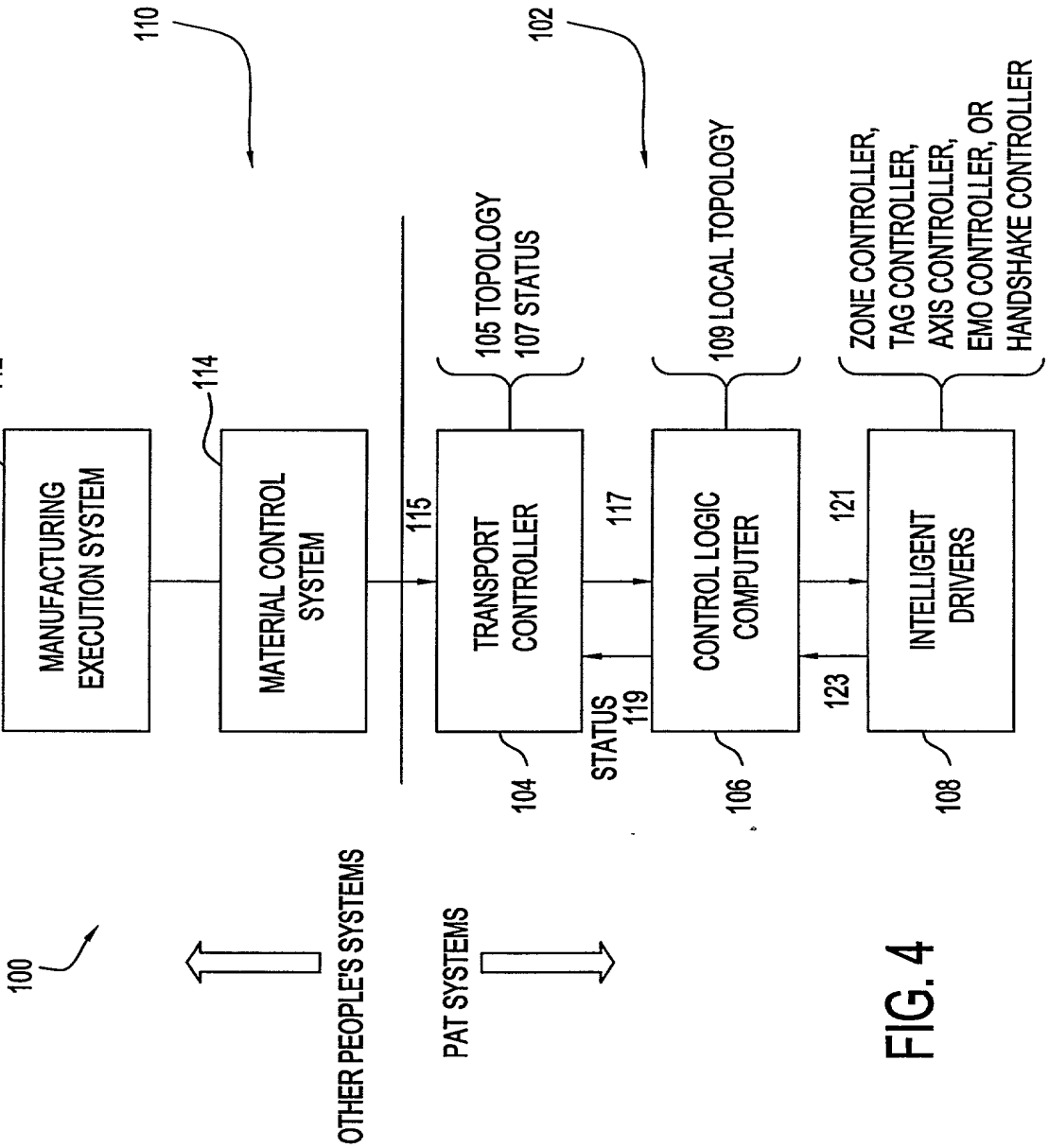

100
OTHER PEOPLE'S SYSTEMS
PAT SYSTEMS
112
MANUFACTURING EXECUTION SYSTEM
114
MATERIAL CONTROL SYSTEM
110
115
104
TRANSPORT CONTROLLER
105 TOPOLOGY
107 STATUS
117
STATUS
119
106
CONTROL LOGIC COMPUTER
102
109 LOCAL TOPOLOGY
121
123
108
INTELLIGENT DRIVERS
ZONE CONTROLLER,
TAG CONTROLLER,
AXIS CONTROLLER,
EMO CONTROLLER, OR
HANDSHAKE CONTROLLER

FIG. 4

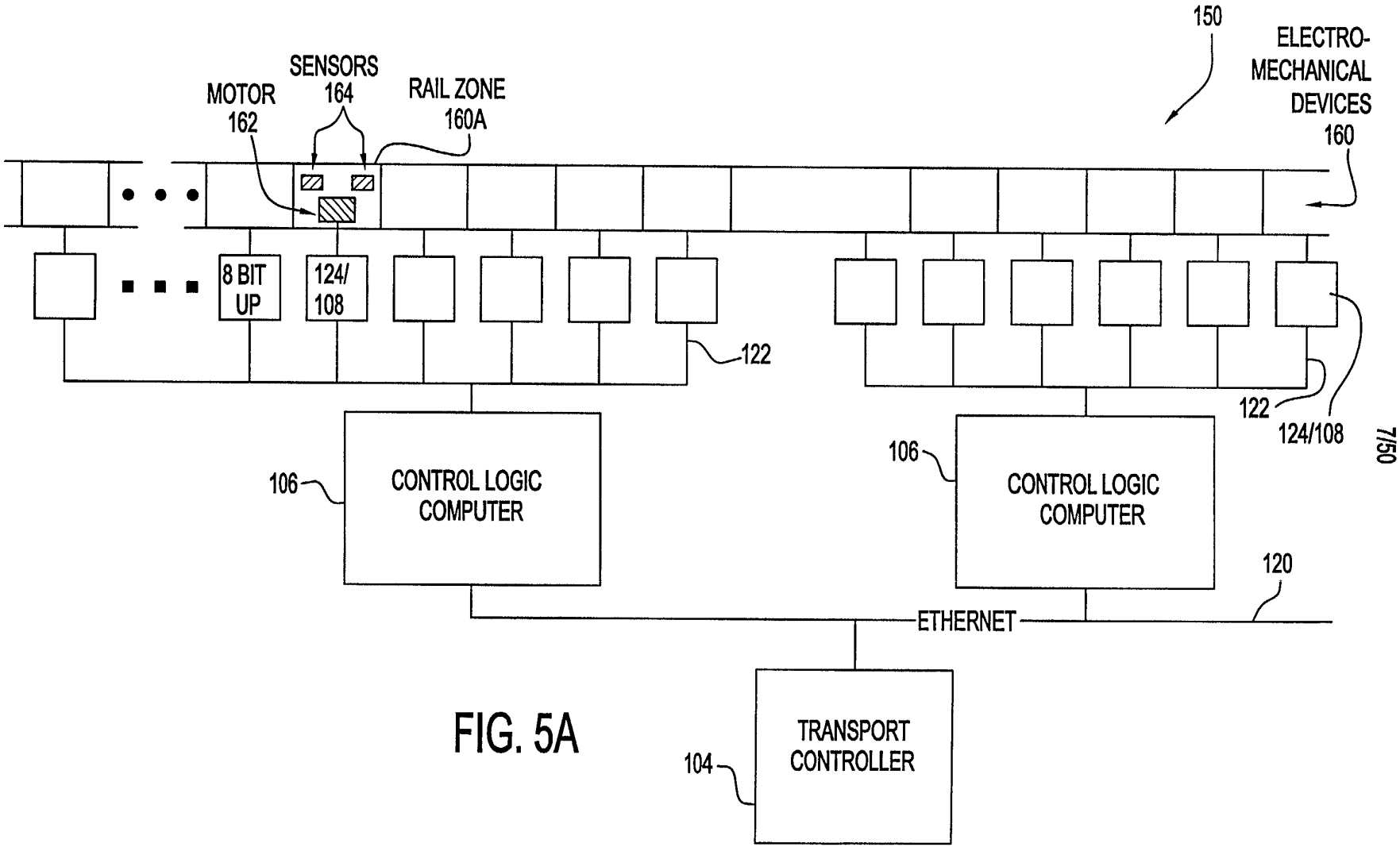

150
ELECTRO-
MECHANICAL
DEVICES
160
SENSORS
164
MOTOR
162
RAIL ZONE
160A
8 BIT
UP
124/
108
122
122
124/108
106
CONTROL LOGIC
COMPUTER
106
CONTROL LOGIC
COMPUTER
120
ETHERNET
104
TRANSPORT
CONTROLLER

FIG. 5A

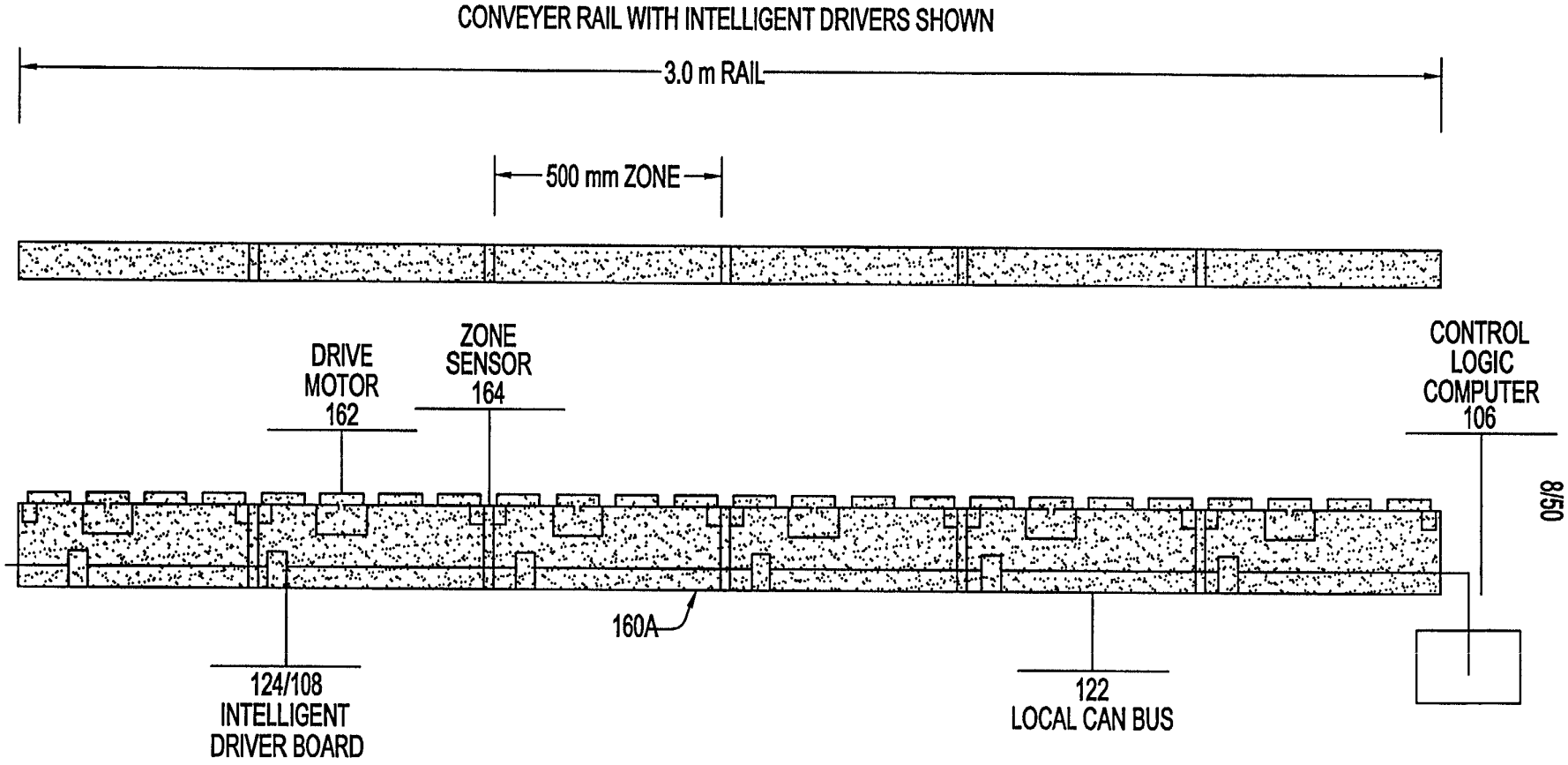

CONVEYER RAIL WITH INTELLIGENT DRIVERS SHOWN
3.0 m RAIL
500 mm ZONE
DRIVE MOTOR 162
ZONE SENSOR 164
CONTROL LOGIC COMPUTER 106
160A
124/108 INTELLIGENT DRIVER BOARD
122 LOCAL CAN BUS

FIG. 5B

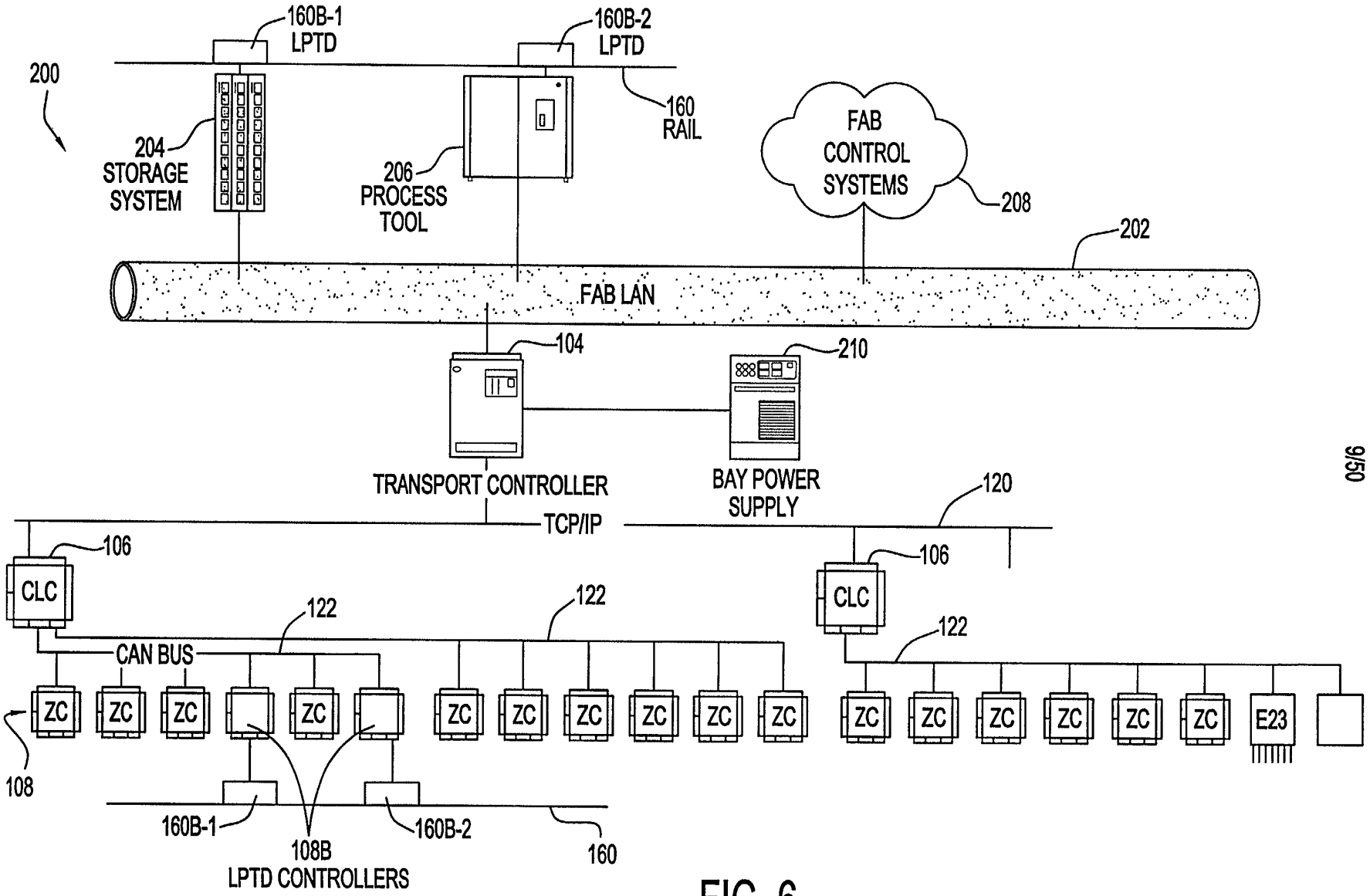

200
160B-1
LPTD
160B-2
LPTD
160
RAIL
204
STORAGE
SYSTEM
206
PROCESS
TOOL
FAB
CONTROL
SYSTEMS
208
202
FAB LAN
104
210
TRANSPORT CONTROLLER
BAY POWER
SUPPLY
120
TCP/IP
106
CLC
106
CLC
122
122
122
CAN BUS
ZC
E23
108
160B-1
160B-2
108B
LPTD CONTROLLERS
160

FIG. 6

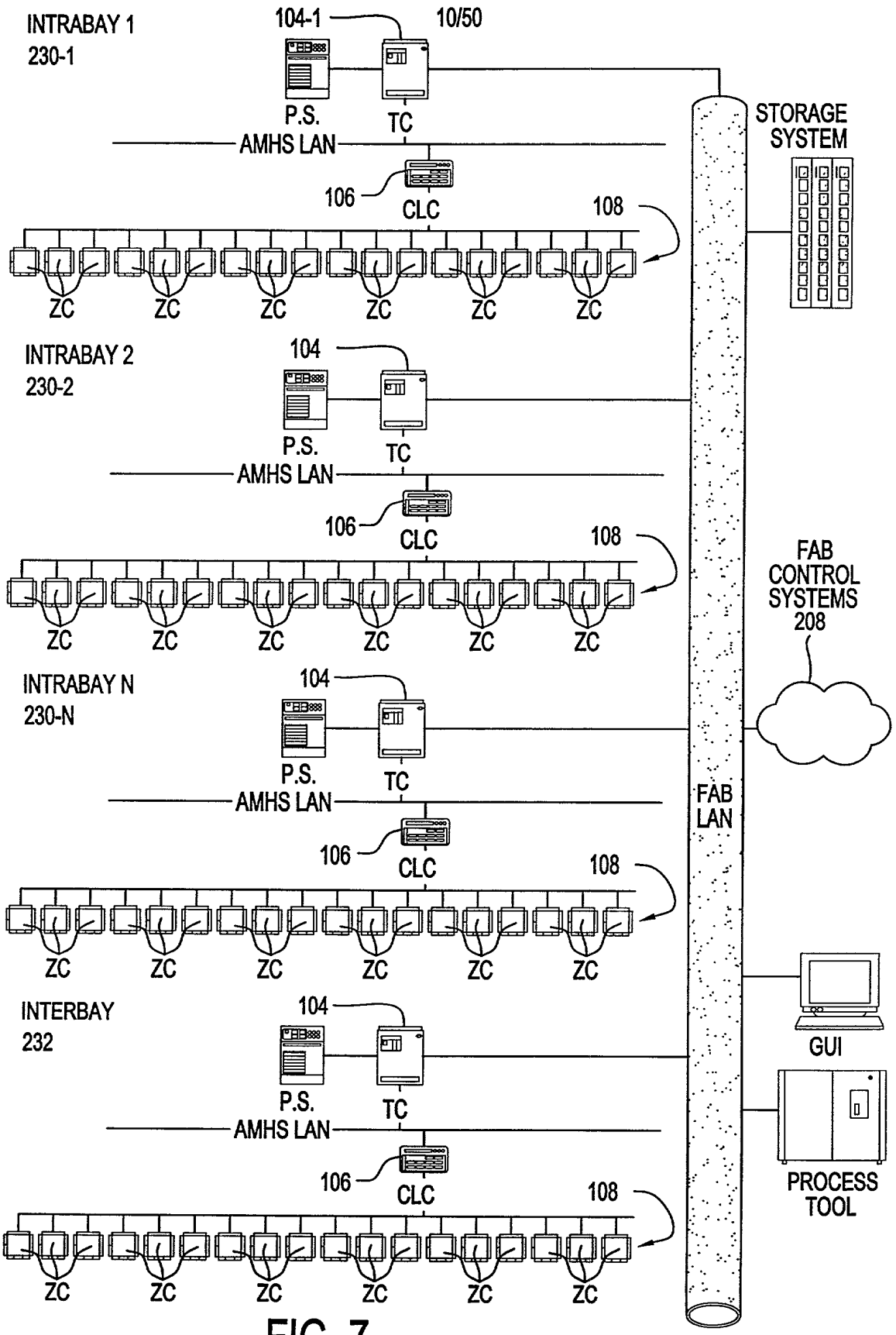

INTRABAY 1
230-1
104-1
10/50
P.S.
TC
AMHS LAN
106
CLC
108
ZC
ZC
ZC
ZC
ZC
ZC
STORAGE SYSTEM
INTRABAY 2
230-2
104
P.S.
TC
AMHS LAN
106
CLC
108
ZC
ZC
ZC
ZC
ZC
ZC
FAB CONTROL SYSTEMS
208
INTRABAY N
230-N
104
P.S.
TC
AMHS LAN
106
CLC
108
ZC
ZC
ZC
ZC
ZC
ZC
FAB LAN
INTERBAY
232
104
P.S.
TC
AMHS LAN
106
CLC
108
ZC
ZC
ZC
ZC
ZC
ZC
GUI
PROCESS TOOL

FIG. 7

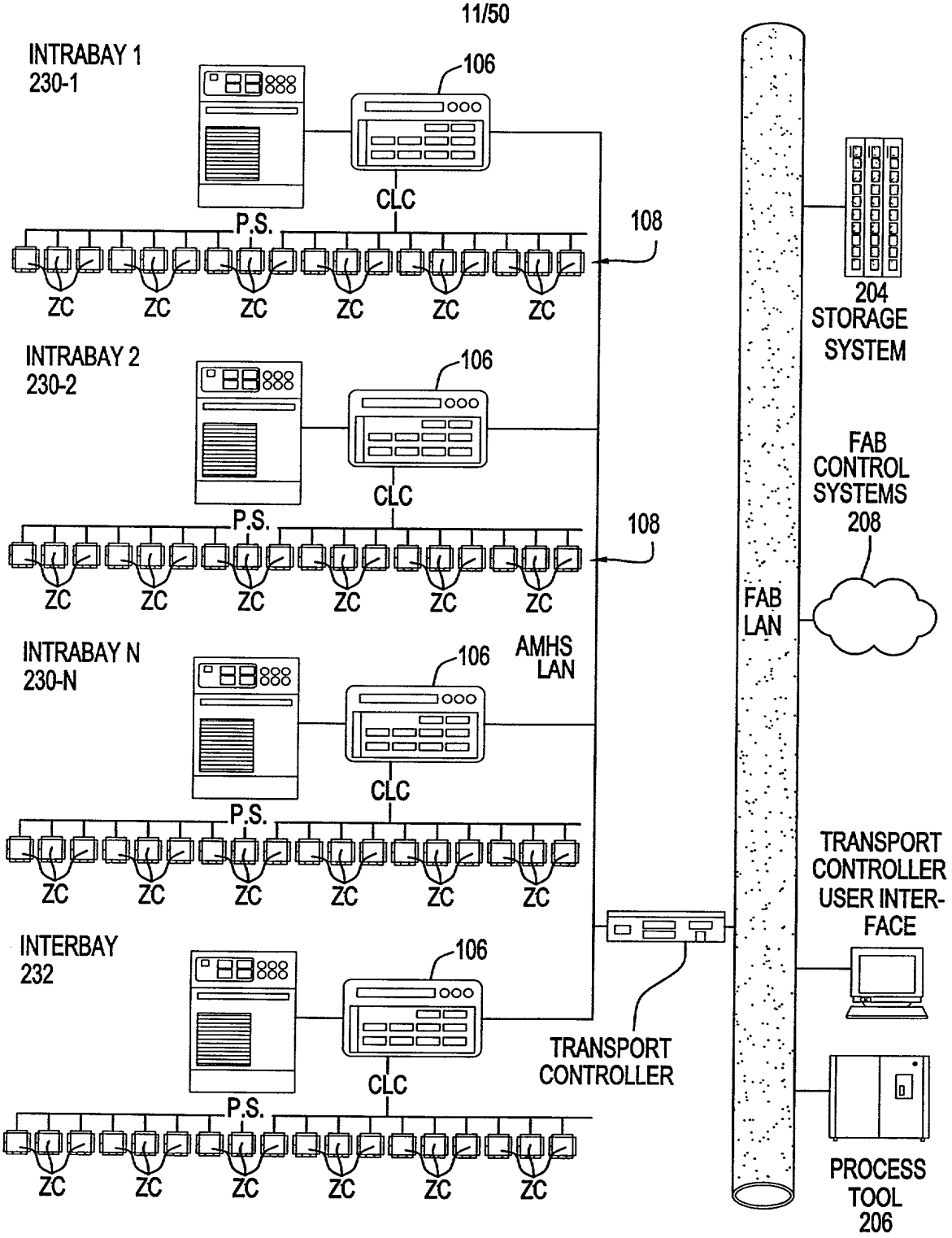

INTRABAY 1
230-1
106
CLC
P.S.
108
ZC
ZC
ZC
ZC
ZC
ZC
INTRABAY 2
230-2
106
CLC
P.S.
108
ZC
ZC
ZC
ZC
ZC
ZC
INTRABAY N
230-N
106
AMHS
LAN
CLC
P.S.
ZC
ZC
ZC
ZC
ZC
ZC
INTERBAY
232
106
CLC
P.S.
ZC
ZC
ZC
ZC
ZC
ZC
TRANSPORT
CONTROLLER
204
STORAGE
SYSTEM
FAB
CONTROL
SYSTEMS
208
FAB
LAN
TRANSPORT
CONTROLLER
USER INTER-
FACE
PROCESS
TOOL
206

FIG. 8

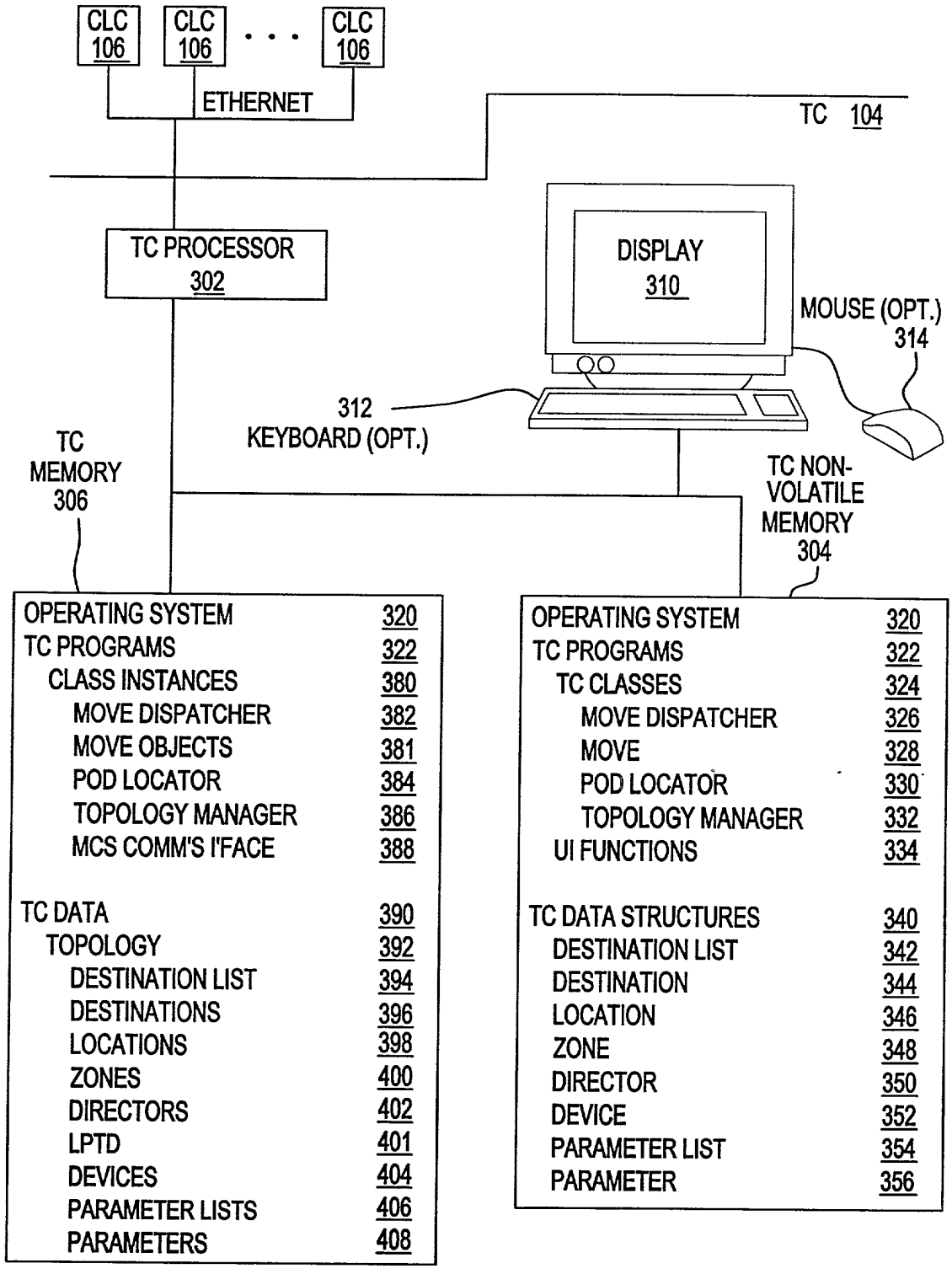

CLC 106
CLC 106
CLC 106
ETHERNET
TC 104
TC PROCESSOR 302
DISPLAY 310
MOUSE (OPT.) 314
312 KEYBOARD (OPT.)
TC MEMORY 306
TC NON-VOLATILE MEMORY 304
OPERATING SYSTEM 320
TC PROGRAMS 322
CLASS INSTANCES 380
MOVE DISPATCHER 382
MOVE OBJECTS 381
POD LOCATOR 384
TOPOLOGY MANAGER 386
MCS COMM'S I'FACE 388
TC DATA 390
TOPOLOGY 392
DESTINATION LIST 394
DESTINATIONS 396
LOCATIONS 398
ZONES 400
DIRECTORS 402
LPTD 401
DEVICES 404
PARAMETER LISTS 406
PARAMETERS 408
OPERATING SYSTEM 320
TC PROGRAMS 322
TC CLASSES 324
MOVE DISPATCHER 326
MOVE 328
POD LOCATOR 330
TOPOLOGY MANAGER 332
UI FUNCTIONS 334
TC DATA STRUCTURES 340
DESTINATION LIST 342
DESTINATION 344
LOCATION 346
ZONE 348
DIRECTOR 350
DEVICE 352
PARAMETER LIST 354
PARAMETER 356

FIG. 9A

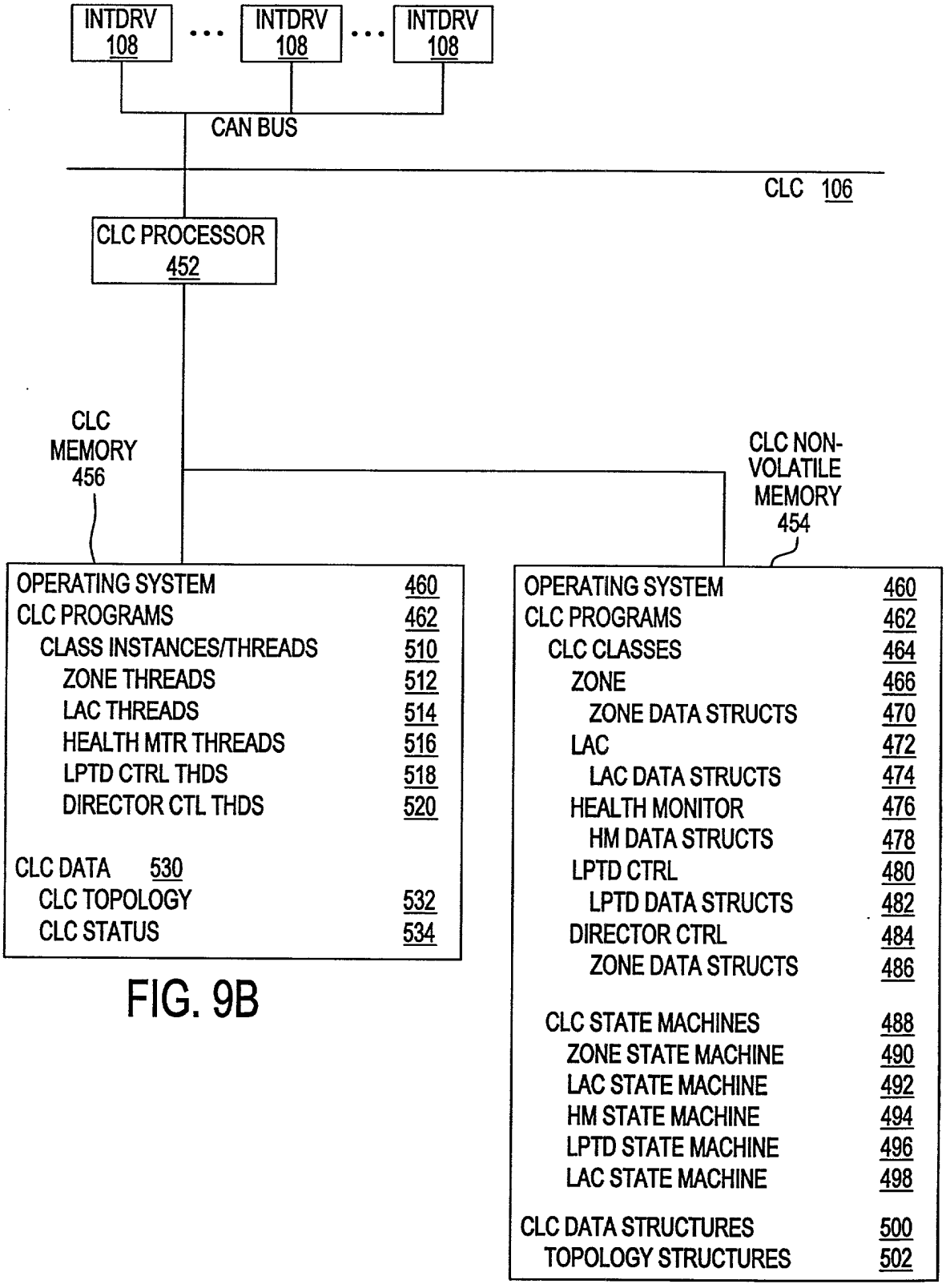

INTDRV 108
INTDRV 108
INTDRV 108
CAN BUS
CLC 106
CLC PROCESSOR 452
CLC MEMORY 456
CLC NON-VOLATILE MEMORY 454
OPERATING SYSTEM 460
CLC PROGRAMS 462
CLASS INSTANCES/THREADS 510
ZONE THREADS 512
LAC THREADS 514
HEALTH MTR THREADS 516
LPTD CTRL THDS 518
DIRECTOR CTL THDS 520
CLC DATA 530
CLC TOPOLOGY 532
CLC STATUS 534
OPERATING SYSTEM 460
CLC PROGRAMS 462
CLC CLASSES 464
ZONE 466
ZONE DATA STRUCTS 470
LAC 472
LAC DATA STRUCTS 474
HEALTH MONITOR 476
HM DATA STRUCTS 478
LPTD CTRL 480
LPTD DATA STRUCTS 482
DIRECTOR CTRL 484
ZONE DATA STRUCTS 486
CLC STATE MACHINES 488
ZONE STATE MACHINE 490
LAC STATE MACHINE 492
HM STATE MACHINE 494
LPTD STATE MACHINE 496
LAC STATE MACHINE 498
CLC DATA STRUCTURES 500
TOPOLOGY STRUCTURES 502

FIG. 9B

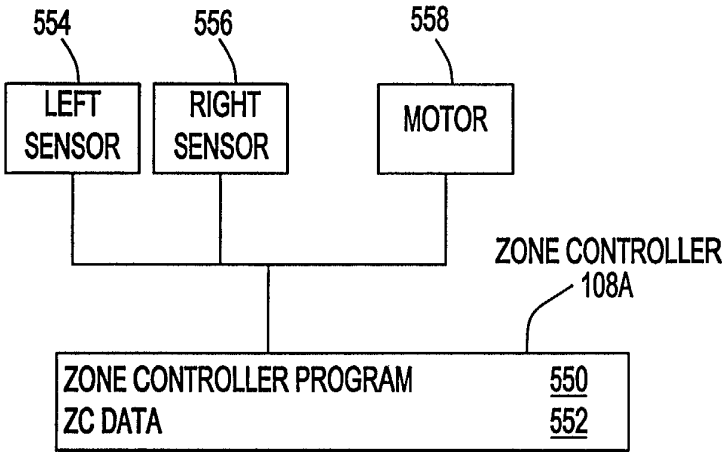



FIG. 9C

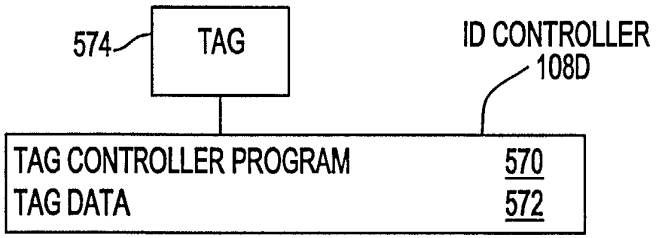



FIG. 9E

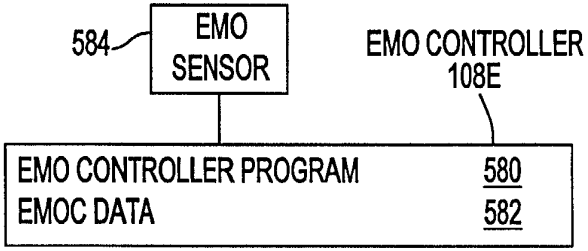



FIG. 9F

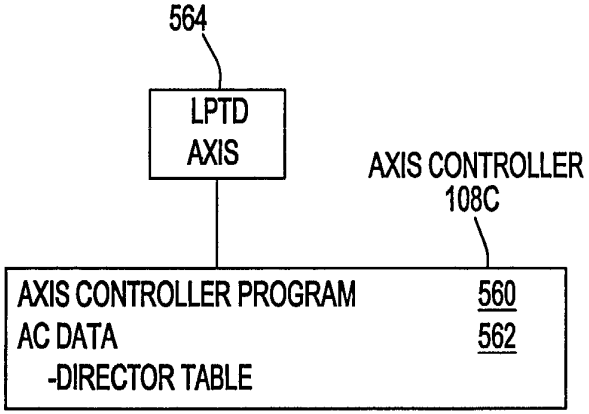



FIG. 9D

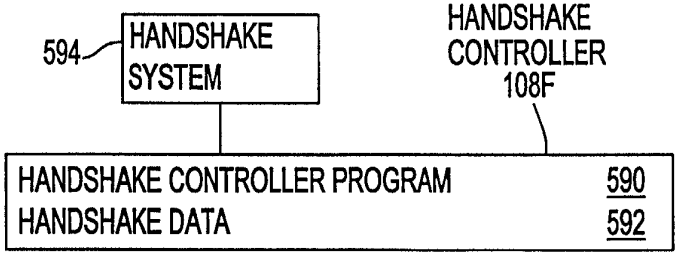



FIG. 9G

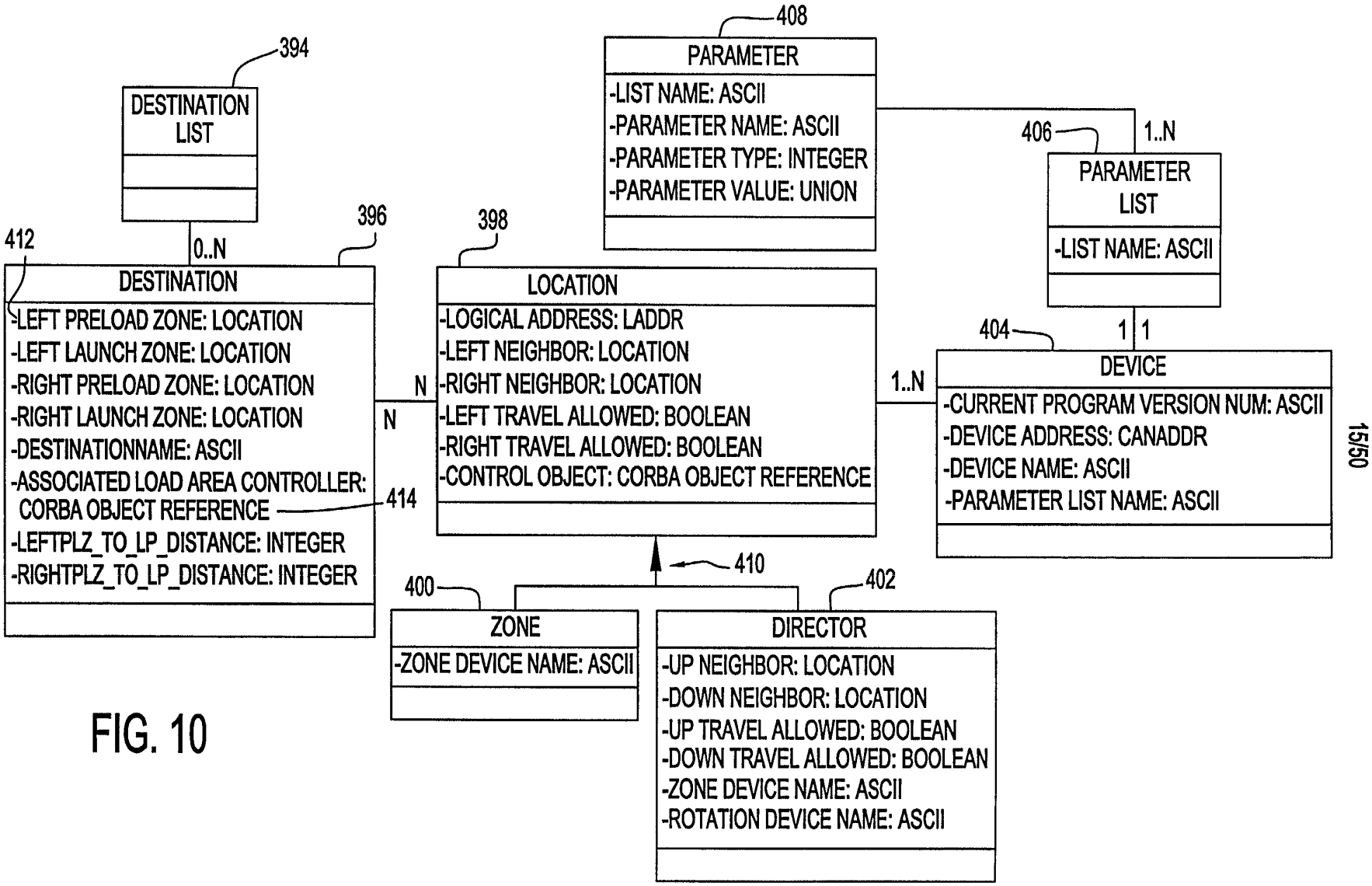



FIG. 10

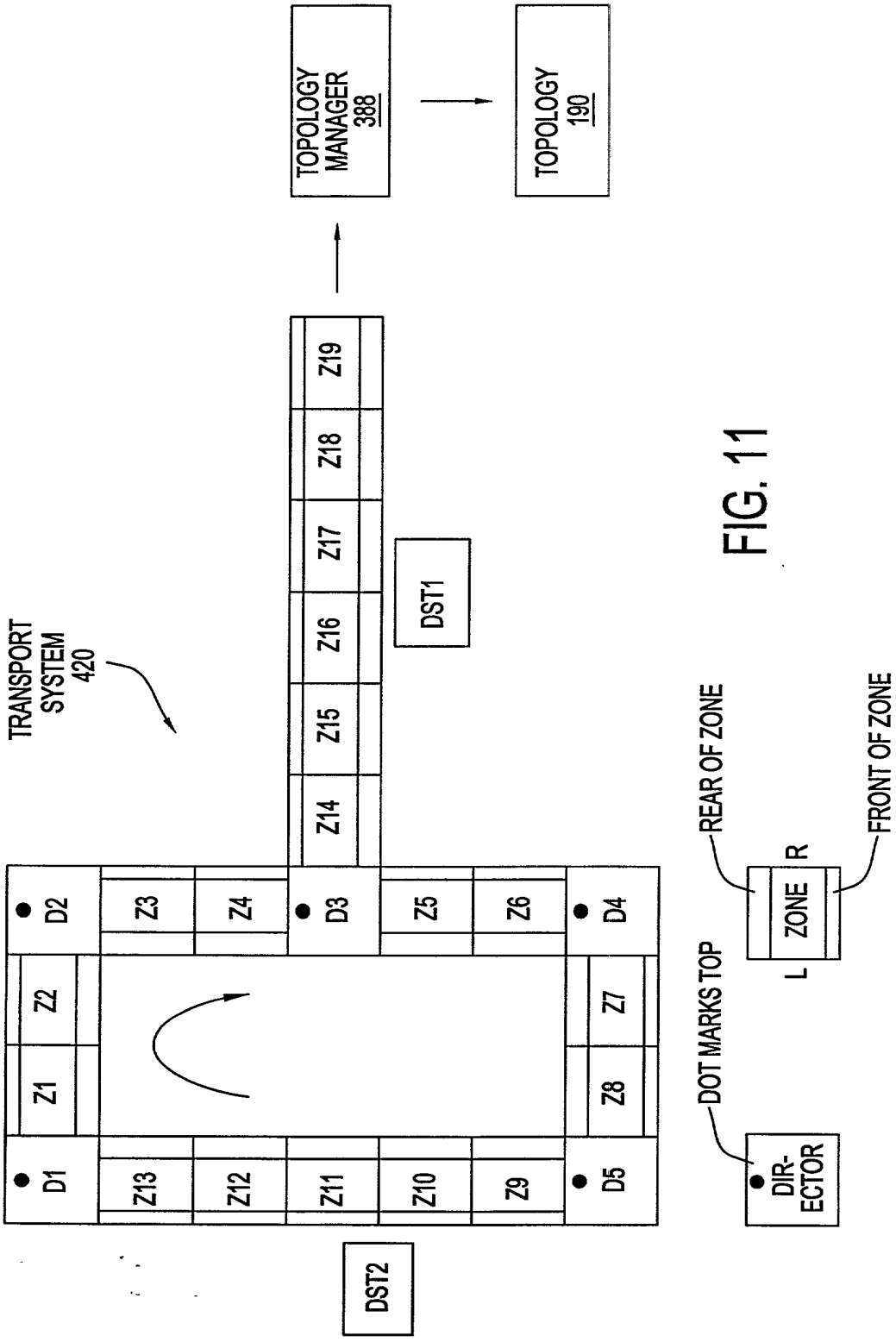

TOPOLOGY MANAGER 388
TOPOLOGY 190
TRANSPORT SYSTEM 420
Z19
Z18
Z17
Z16
Z15
Z14
DST1
D1
D2
D3
D4
D5
Z1
Z2
Z3
Z4
Z5
Z6
Z7
Z8
Z9
Z10
Z11
Z12
Z13
DST2
REAR OF ZONE
FRONT OF ZONE
L
ZONE
R
DOT MARKS TOP
DIR-ECTOR

FIG. 11

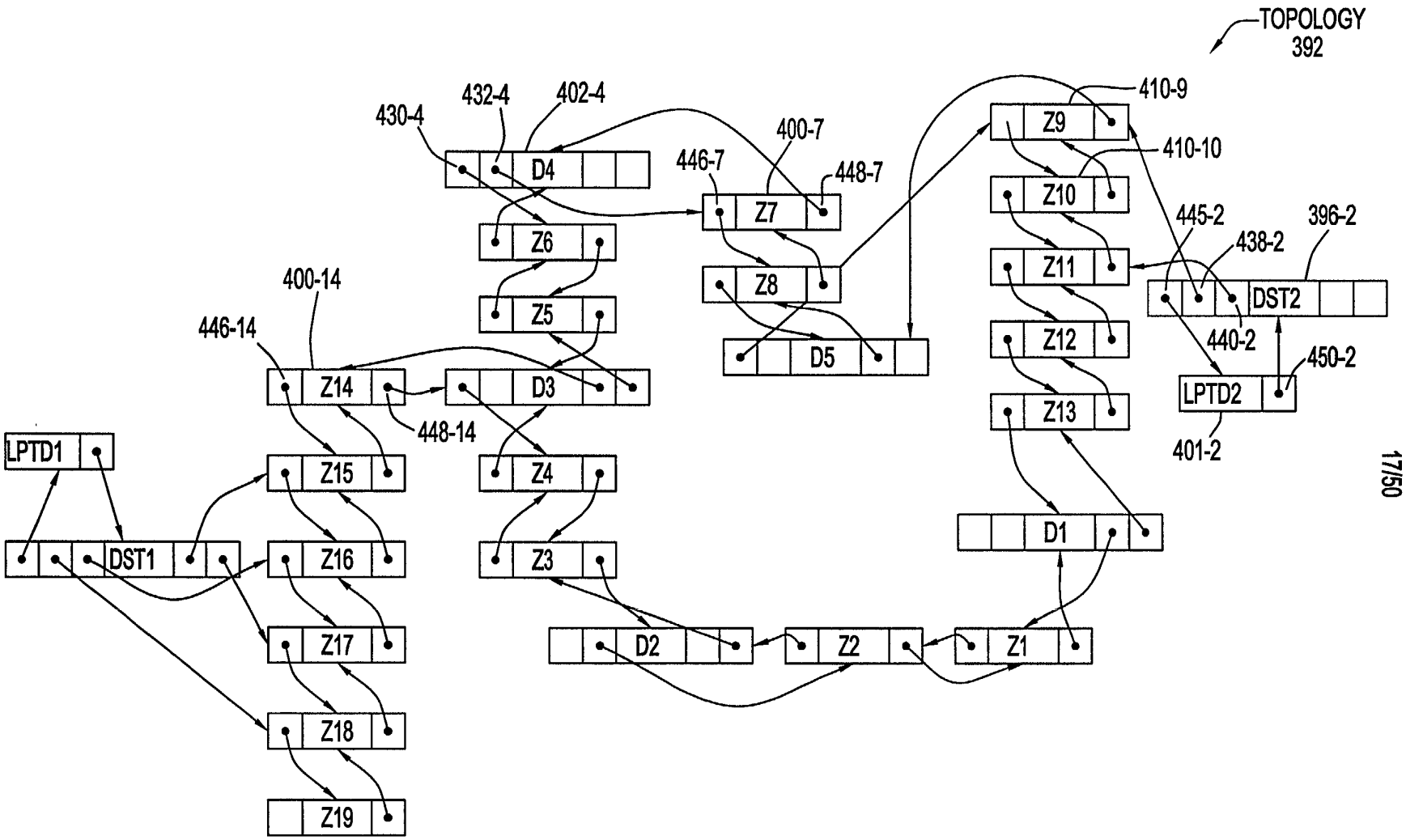



FIG. 12A

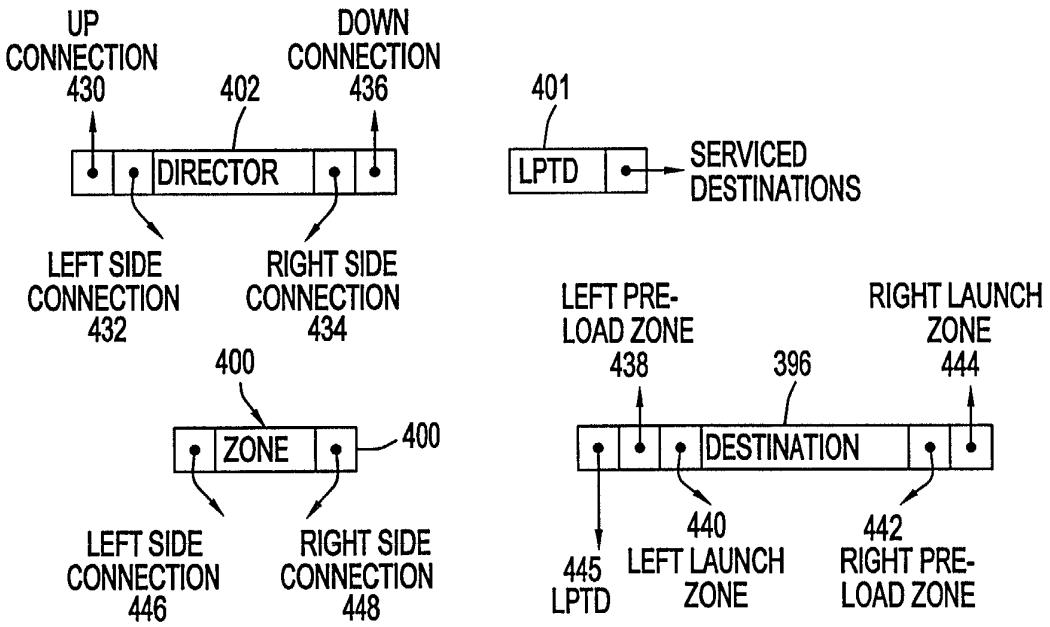
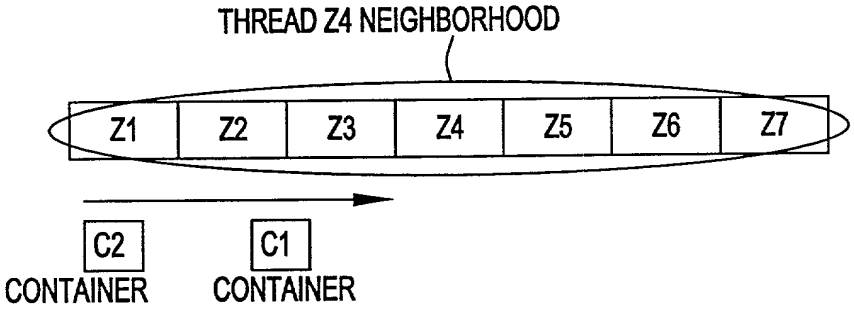



FIG. 12B




ZONE Z4 THREAD 512-4

| | |
|---|---|
| ZONE STATE MACHINE | 620 |
| ZONE THREAD METHODS | 622 |
| ZONE Z4 DATA | 624 |
| NEIGHBOR STATUS: | 626 |
| ZONE Z1 STATUS | 628 |
| STATUS {CARRIER EXITING, CARRIER EXITED, CARRIER STOPPED, CARRIER REMOVED, ZONE AVAILABLE, ZONE RESERVED}; | |
| MAXIMUM SPEED; | 630 |
| ZONE Z2 STATUS | 632 |
| ZONE Z3 STATUS | 634 |
| ZONE Z5 STATUS | 636 |
| ZONE Z6 STATUS | 638 |
| ZONE Z7 STATUS | 640 |
| CONTAINERS QUEUE | 642 |
| CONTAINER C1 | 644 |
| CONTAINER C2 | 646 |
| NEAREST CONTAINER PTR (=C1) | 648 |
| . . . | |
| DOWNSTREAM SPEED TABLE; | 670 |
| UPSTREAM SPEED COMMAND; | 672 |
| MAXIMUM SPEED; | 674 |
| SPEED TABLE RULES) | 676 |

FIG. 13

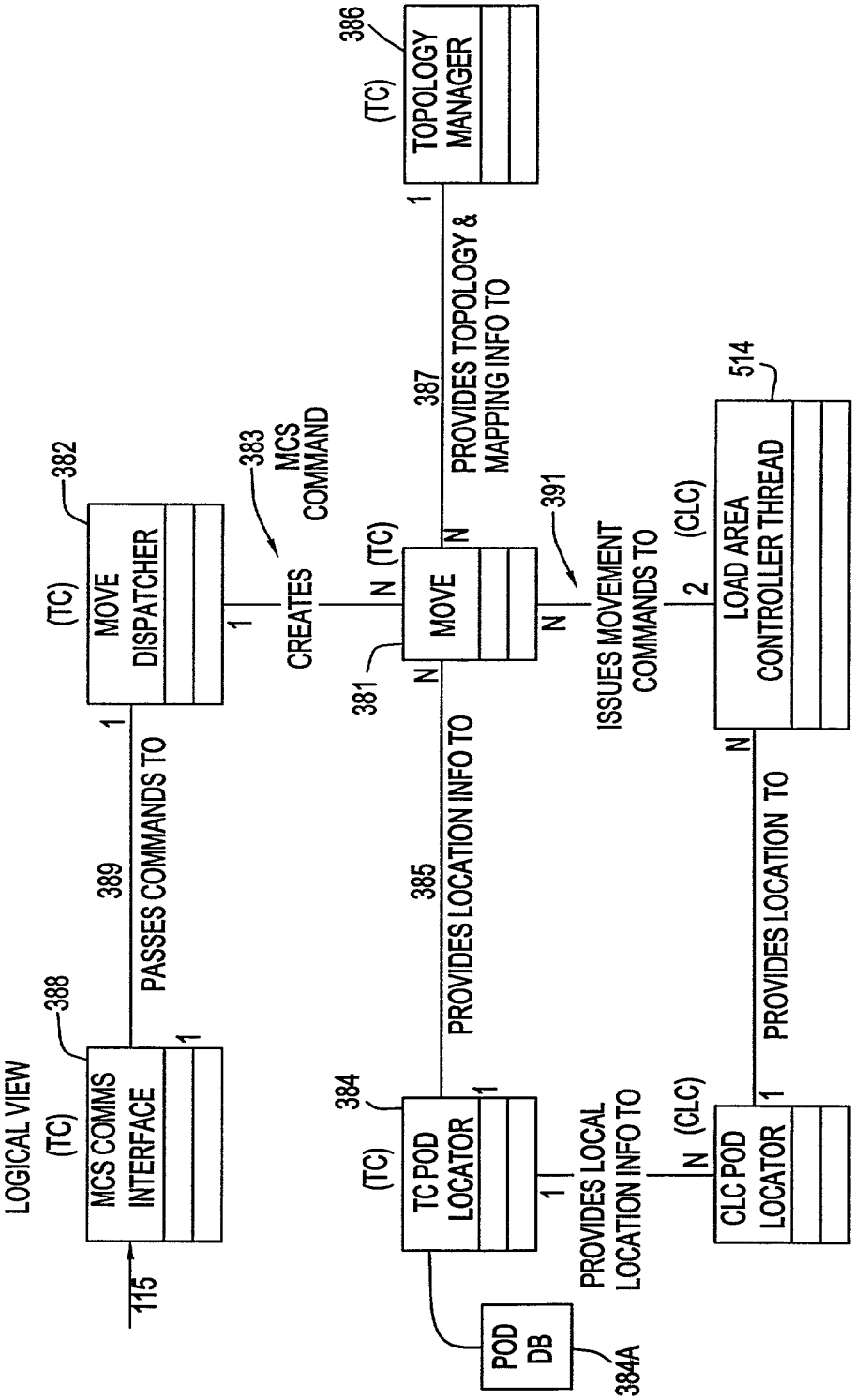

LOGICAL VIEW
(TC)
MCS COMMS INTERFACE
388
115
1
389
PASSES COMMANDS TO
1
(TC)
MOVE DISPATCHER
382
1
CREATES
383
MCS COMMAND
N (TC)
MOVE
381
N
385
PROVIDES LOCATION INFO TO
(TC)
TC POD LOCATOR
384
1
POD DB
384A
1
PROVIDES LOCAL LOCATION INFO TO
N (CLC)
CLC POD LOCATOR
1
PROVIDES LOCATION TO
N
2 (CLC)
LOAD AREA CONTROLLER THREAD
514
N
ISSUES MOVEMENT COMMANDS TO
391
N
387
PROVIDES TOPOLOGY & MAPPING INFO TO
1
(TC)
TOPOLOGY MANAGER
386

FIG. 14

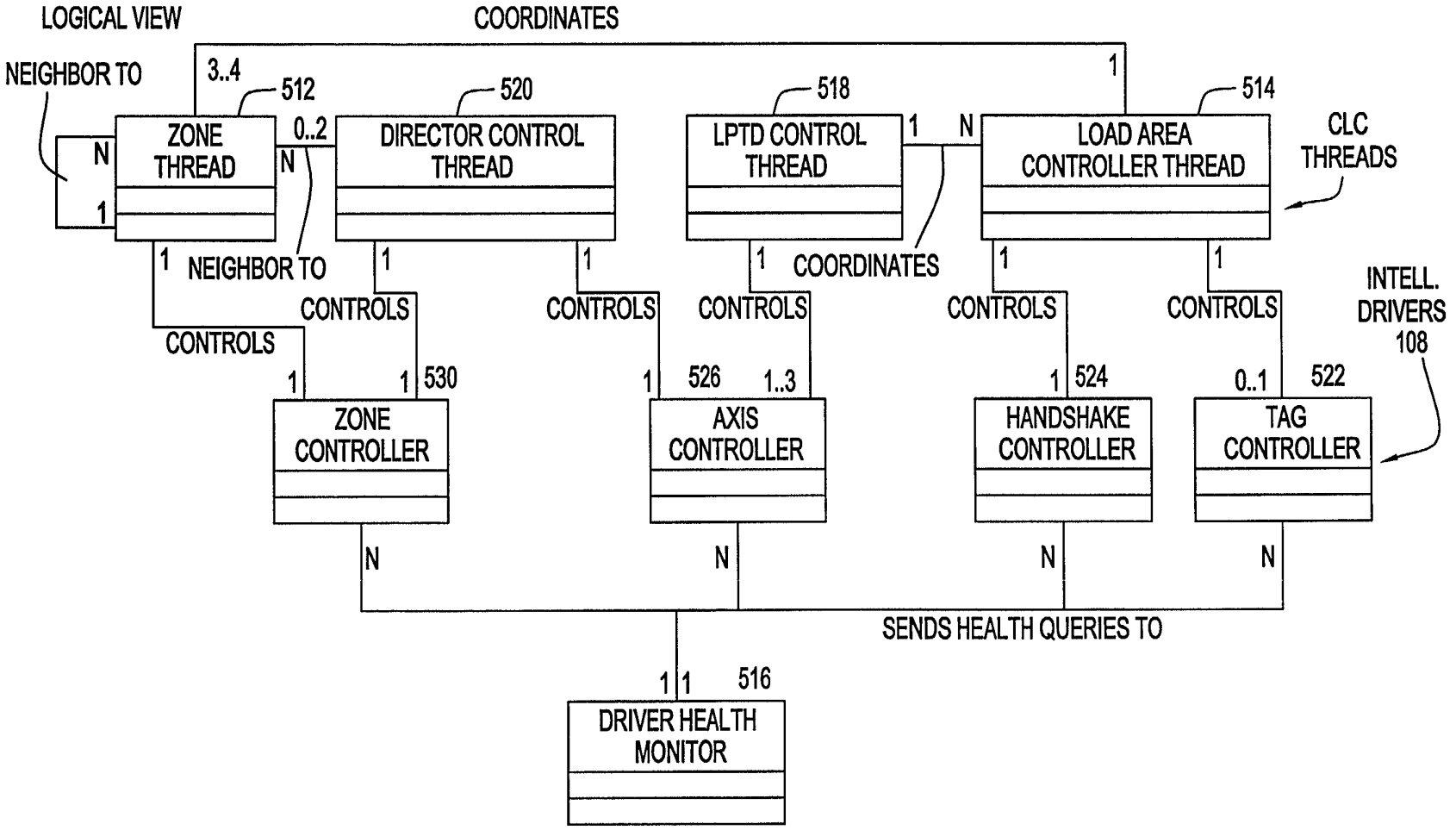
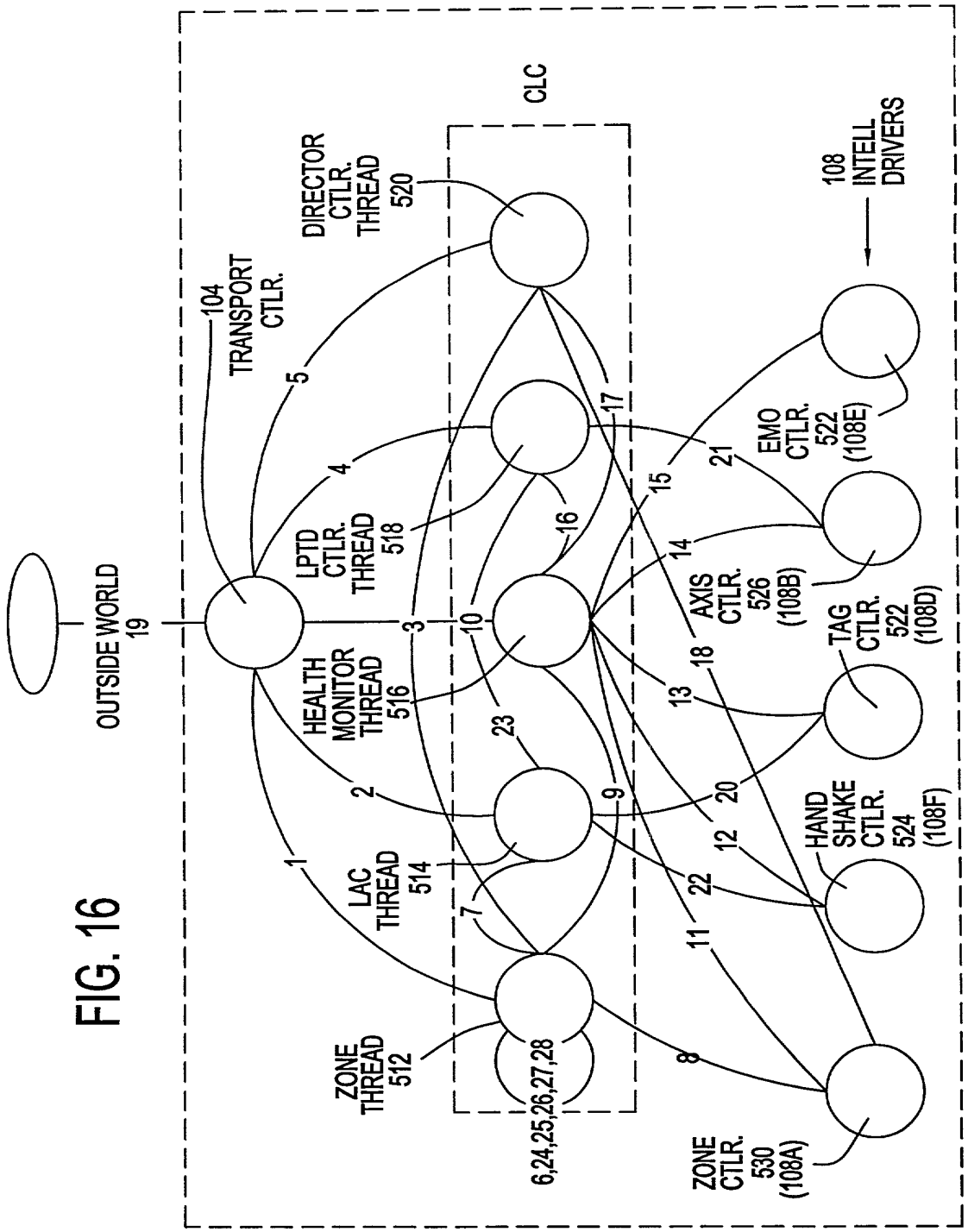

LOGICAL VIEW
COORDINATES
NEIGHBOR TO
3..4
512
520
518
514
1
ZONE THREAD
0..2
DIRECTOR CONTROL THREAD
LPTD CONTROL THREAD
LOAD AREA CONTROLLER THREAD
CLC THREADS
N
1
N
1
N
NEIGHBOR TO
COORDINATES
CONTROLS
CONTROLS
CONTROLS
CONTROLS
CONTROLS
INTELL. DRIVERS 108
1
1
530
526
1..3
524
0..1
522
ZONE CONTROLLER
AXIS CONTROLLER
HANDSHAKE CONTROLLER
TAG CONTROLLER
N
N
N
N
SENDS HEALTH QUERIES TO
1
1
516
DRIVER HEALTH MONITOR

FIG. 15

FIG. 16


OUTSIDE WORLD
19
104
TRANSPORT
CTLR.
DIRECTOR
CTLR.
THREAD
520
CLC
108
INTELL
DRIVERS
LPTD
CTLR.
THREAD
518
HEALTH
MONITOR
THREAD
516
LAC
THREAD
514
ZONE
THREAD
512
6,24,25,26,27,28
EMO
CTLR.
522
(108E)
AXIS
CTLR.
526
(108B)
TAG
CTLR.
522
(108D)
HAND
SHAKE
CTLR.
524
(108F)
ZONE
CTLR.
530
(108A)
PAT AMHS SYSTEM
1
2
3
4
5
7
8
9
10
11
12
13
14
15
16
17
18
20
21
22
23

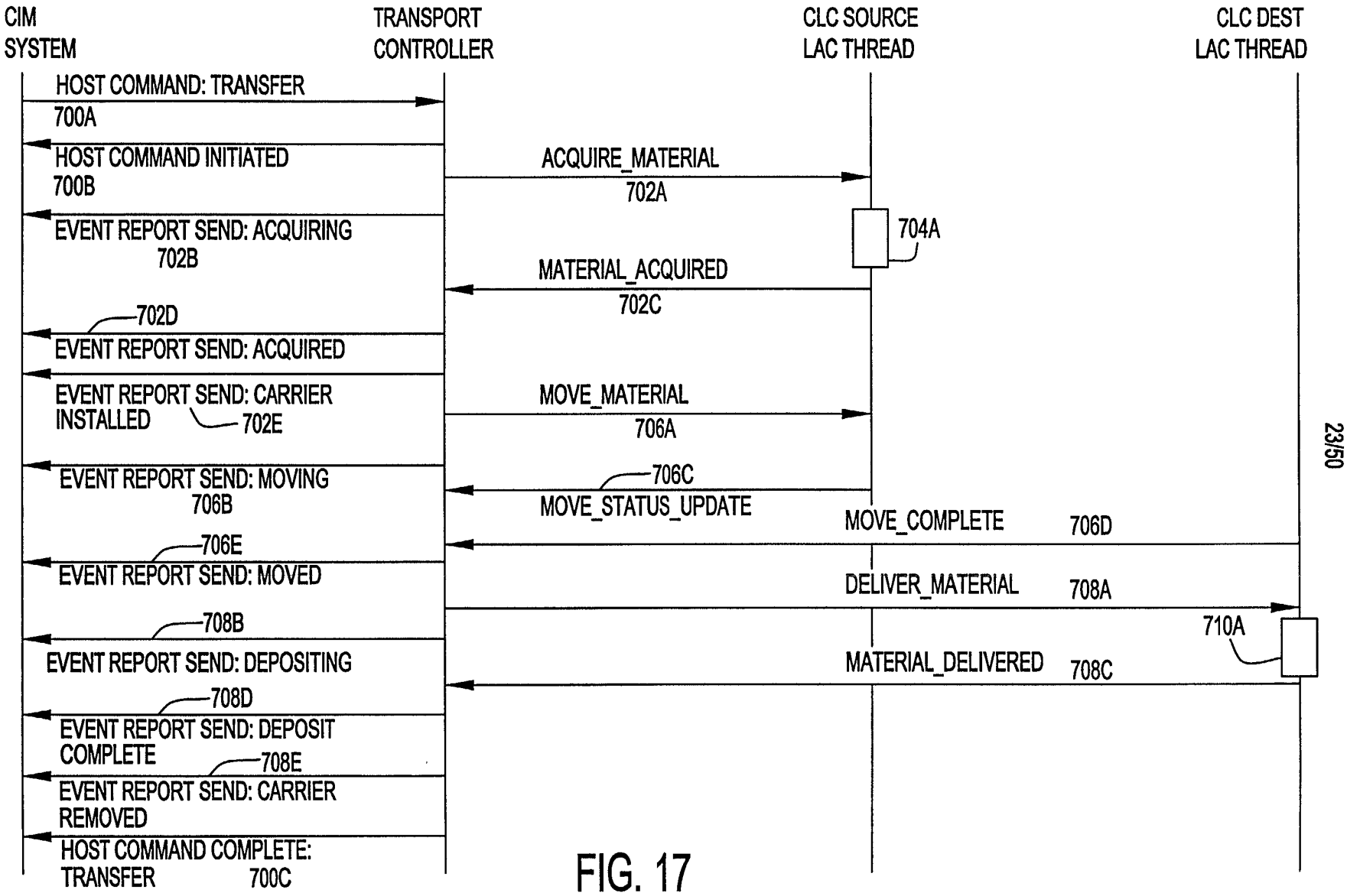

CIM SYSTEM
TRANSPORT CONTROLLER
CLC SOURCE LAC THREAD
CLC DEST LAC THREAD
HOST COMMAND: TRANSFER
700A
HOST COMMAND INITIATED
700B
ACQUIRE_MATERIAL
702A
704A
EVENT REPORT SEND: ACQUIRING
702B
MATERIAL_ACQUIRED
702C
702D
EVENT REPORT SEND: ACQUIRED
EVENT REPORT SEND: CARRIER INSTALLED
702E
MOVE_MATERIAL
706A
EVENT REPORT SEND: MOVING
706B
706C
MOVE_STATUS_UPDATE
MOVE_COMPLETE
706D
706E
EVENT REPORT SEND: MOVED
DELIVER_MATERIAL
708A
710A
708B
EVENT REPORT SEND: DEPOSITING
MATERIAL_DELIVERED
708C
708D
EVENT REPORT SEND: DEPOSIT COMPLETE
708E
EVENT REPORT SEND: CARRIER REMOVED
HOST COMMAND COMPLETE: TRANSFER
700C

FIG. 17

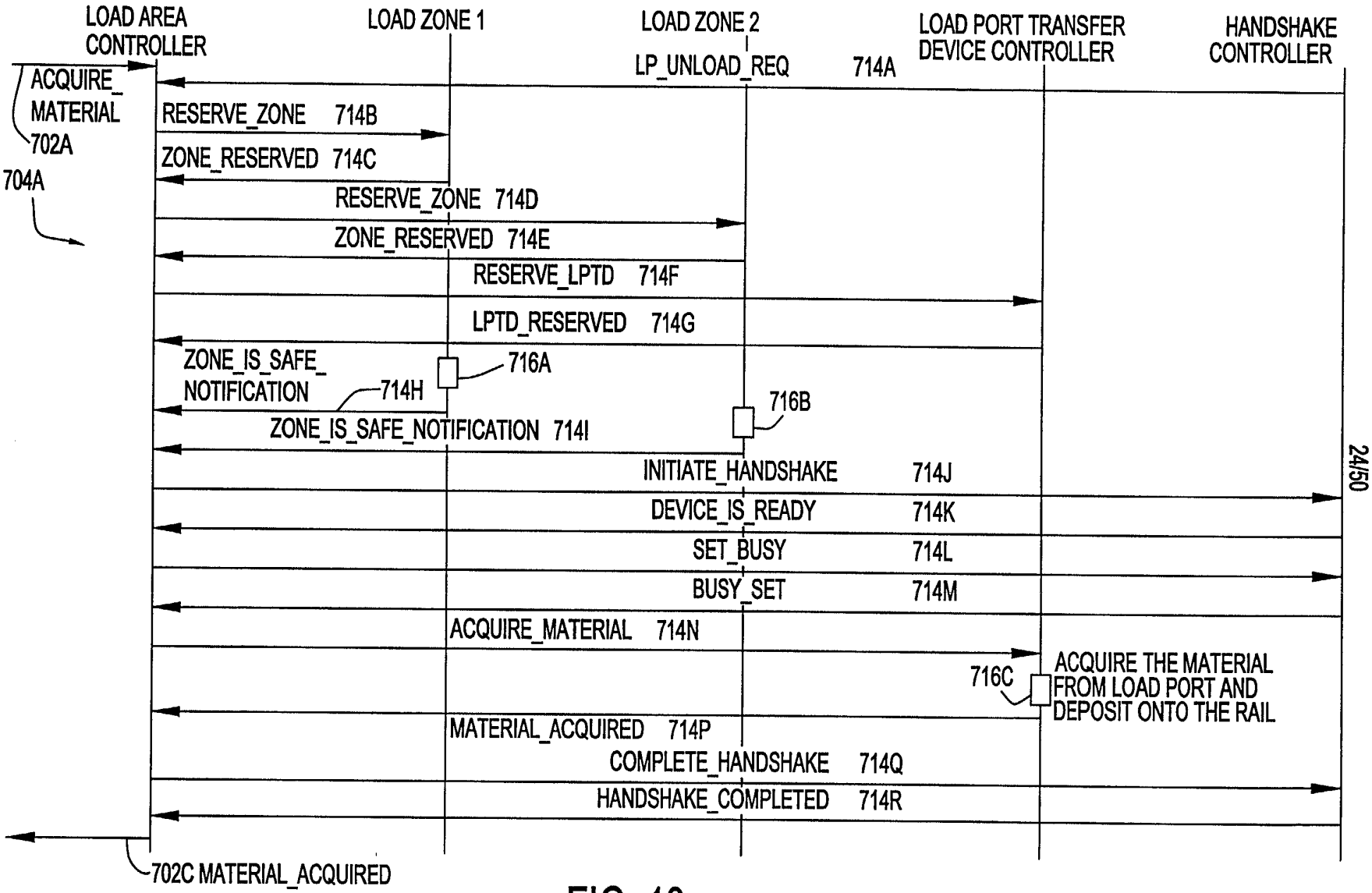

LOAD AREA CONTROLLER
LOAD ZONE 1
LOAD ZONE 2
LOAD PORT TRANSFER DEVICE CONTROLLER
HANDSHAKE CONTROLLER
ACQUIRE_ MATERIAL
702A
704A
LP_UNLOAD_REQ 714A
RESERVE_ZONE 714B
ZONE_RESERVED 714C
RESERVE_ZONE 714D
ZONE_RESERVED 714E
RESERVE_LPTD 714F
LPTD_RESERVED 714G
ZONE_IS_SAFE_ NOTIFICATION
714H
716A
716B
ZONE_IS_SAFE_NOTIFICATION 714I
INITIATE_HANDSHAKE 714J
DEVICE_IS_READY 714K
SET_BUSY 714L
BUSY_SET 714M
ACQUIRE_MATERIAL 714N
716C
ACQUIRE THE MATERIAL FROM LOAD PORT AND DEPOSIT ONTO THE RAIL
MATERIAL_ACQUIRED 714P
COMPLETE_HANDSHAKE 714Q
HANDSHAKE_COMPLETED 714R
702C MATERIAL_ACQUIRED
24/50

FIG. 18

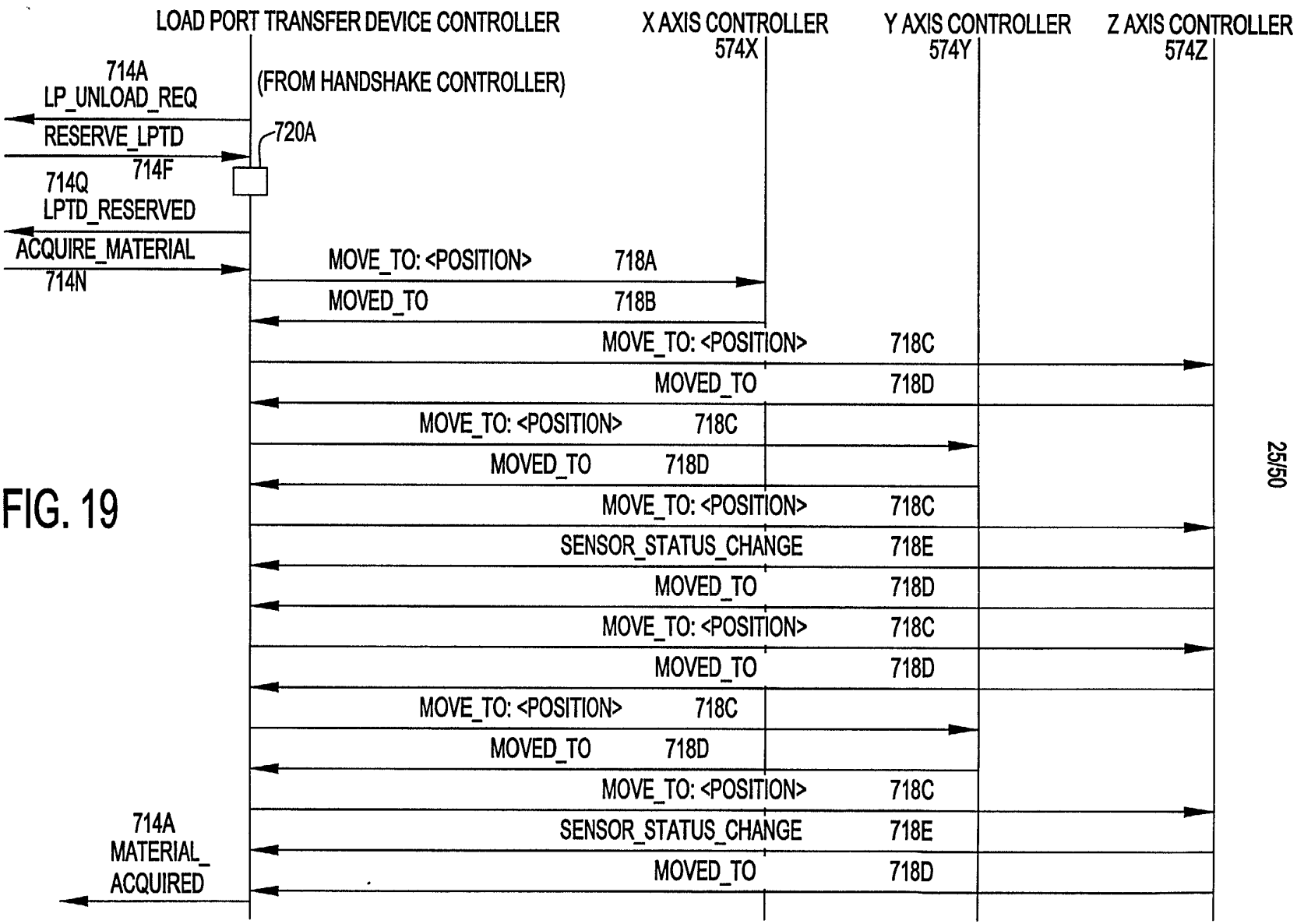

LOAD PORT TRANSFER DEVICE CONTROLLER
X AXIS CONTROLLER 574X
Y AXIS CONTROLLER 574Y
Z AXIS CONTROLLER 574Z
714A LP_UNLOAD_REQ
(FROM HANDSHAKE CONTROLLER)
RESERVE_LPTD 714F
720A
714Q LPTD_RESERVED
ACQUIRE_MATERIAL 714N
MOVE_TO: <POSITION> 718A
MOVED_TO 718B
MOVE_TO: <POSITION> 718C
MOVED_TO 718D
MOVE_TO: <POSITION> 718C
MOVED_TO 718D
MOVE_TO: <POSITION> 718C
SENSOR_STATUS_CHANGE 718E
MOVED_TO 718D
MOVE_TO: <POSITION> 718C
MOVED_TO 718D
MOVE_TO: <POSITION> 718C
MOVED_TO 718D
MOVE_TO: <POSITION> 718C
SENSOR_STATUS_CHANGE 718E
MOVED_TO 718D
714A MATERIAL_ ACQUIRED

FIG. 19

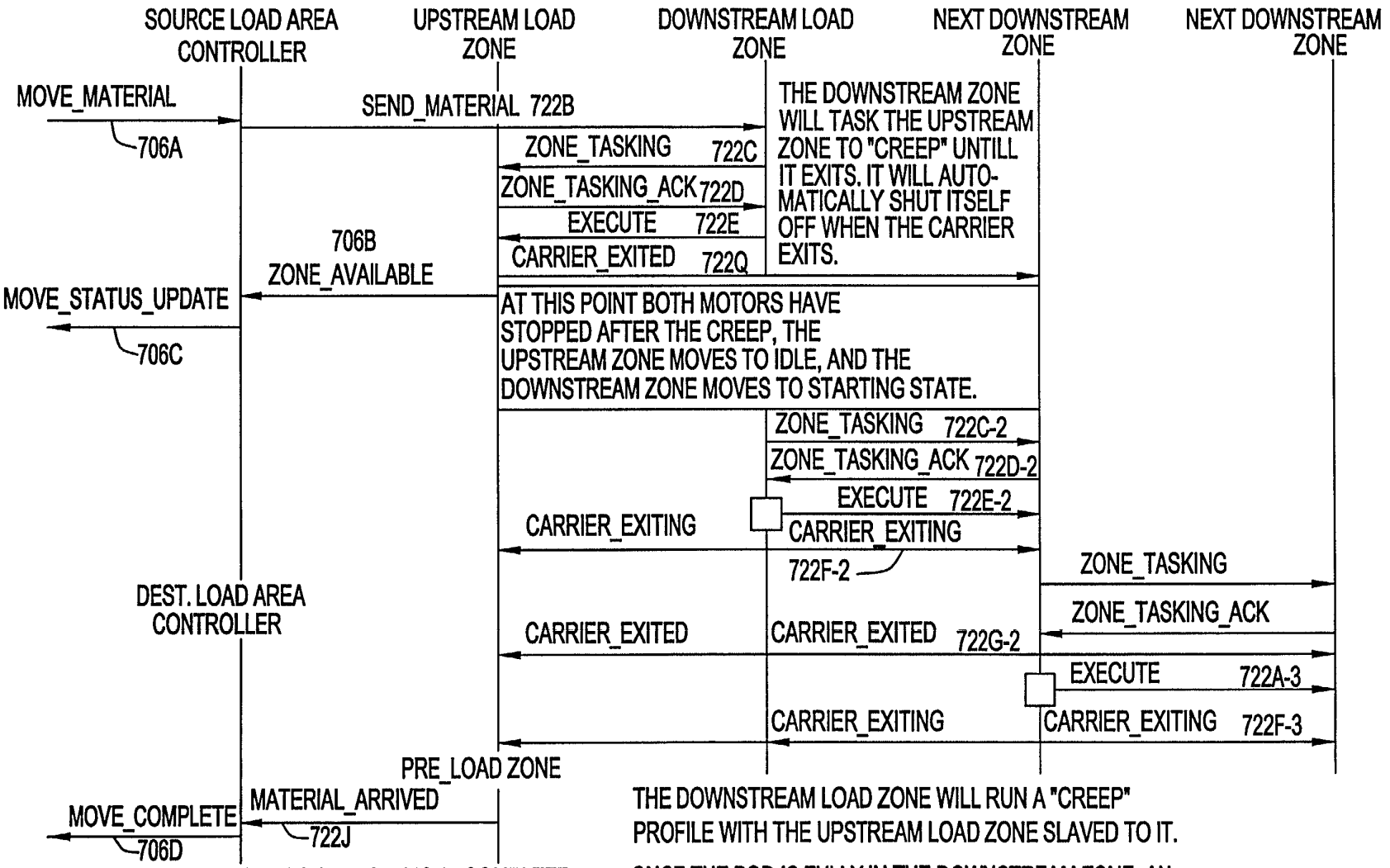
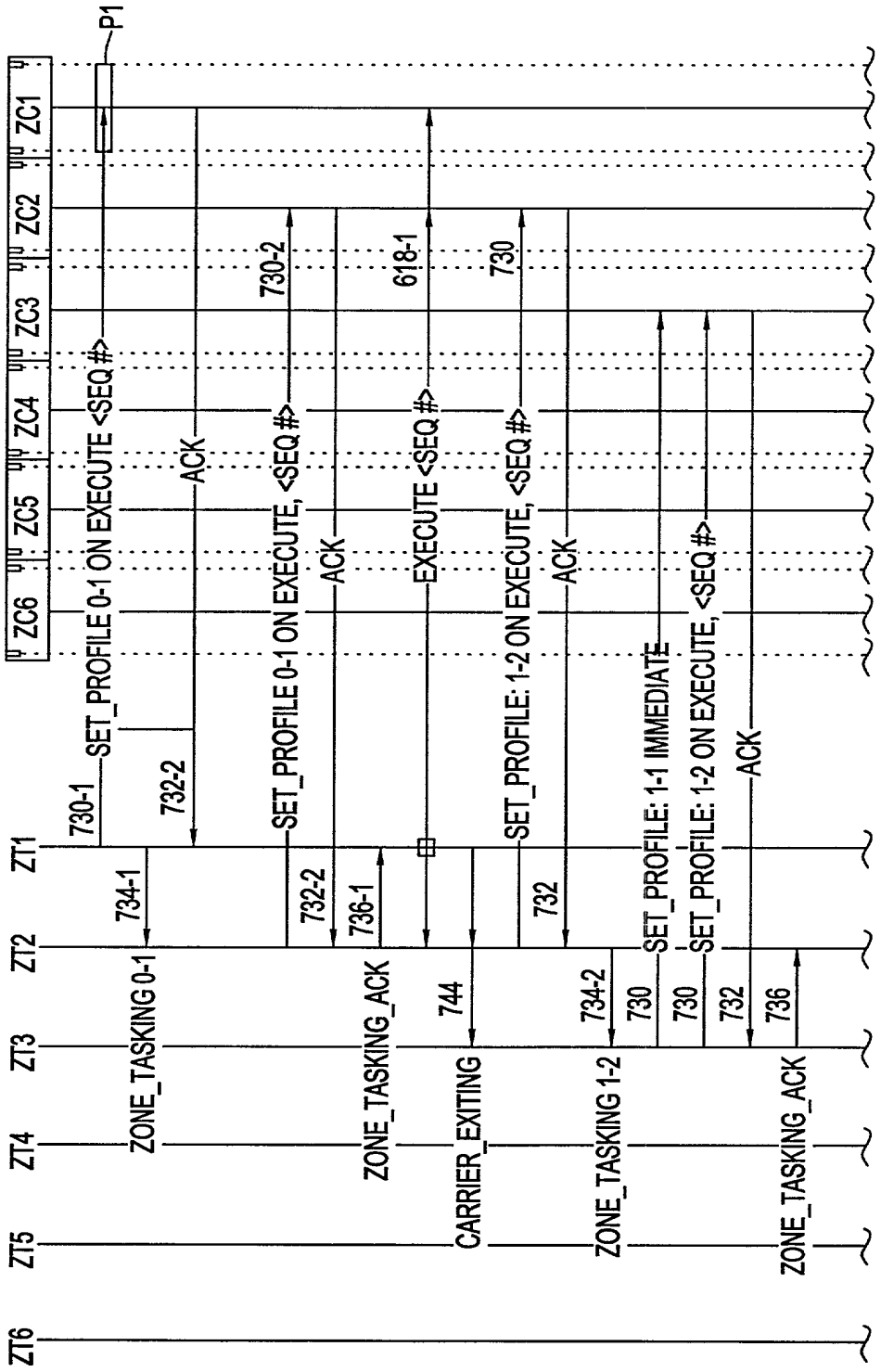



FIG. 20




CONTINUED TO FIG. 21B

FIG. 21 A

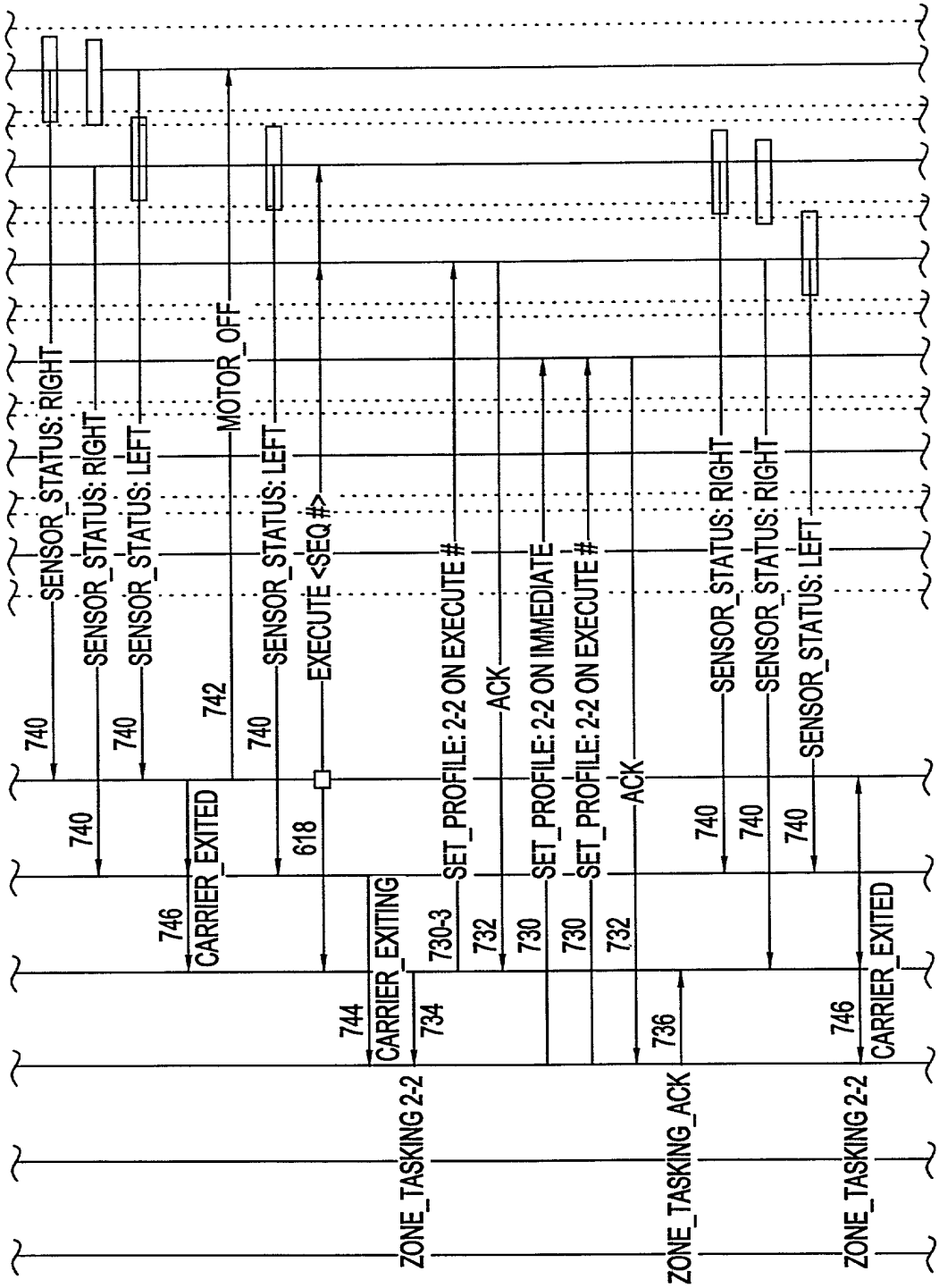

ZONE_TASKING 2-2
ZONE_TASKING_ACK
ZONE_TASKING 2-2
744
CARRIER_EXITING
734
746
CARRIER_EXITED
746
740
SENSOR_STATUS: RIGHT
740
SENSOR_STATUS: RIGHT
740
SENSOR_STATUS: LEFT
742
MOTOR_OFF
740
SENSOR_STATUS: LEFT
618
EXECUTE <SEQ #>
730-3
SET_PROFILE: 2-2 ON EXECUTE #
732
ACK
730
SET_PROFILE: 2-2 ON IMMEDIATE
730
SET_PROFILE: 2-2 ON EXECUTE #
732
ACK
736
740
SENSOR_STATUS: RIGHT
740
SENSOR_STATUS: RIGHT
740
SENSOR_STATUS: LEFT
746
CARRIER_EXITED
CONTINUED TO FIG. 21C

FIG. 21B

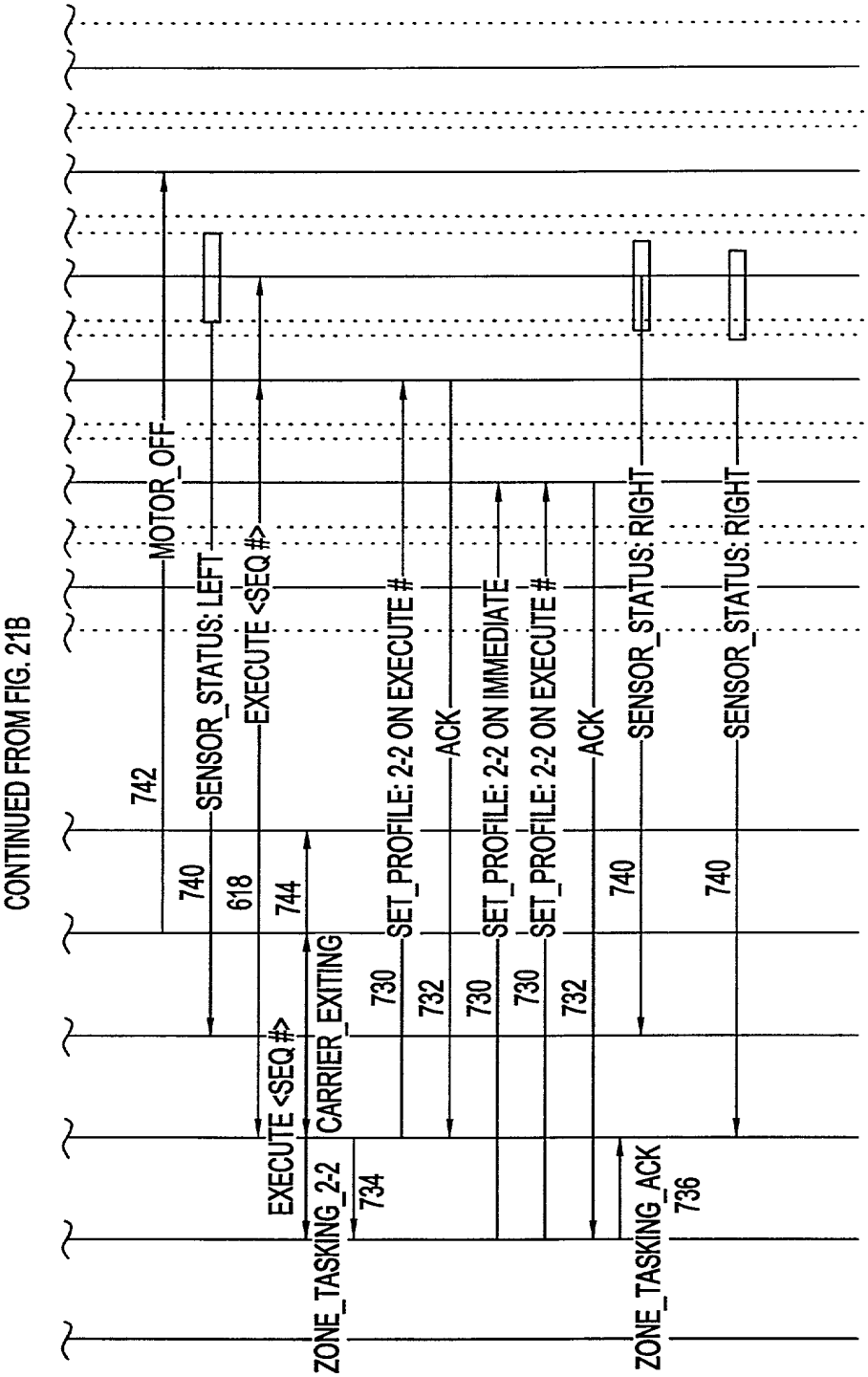
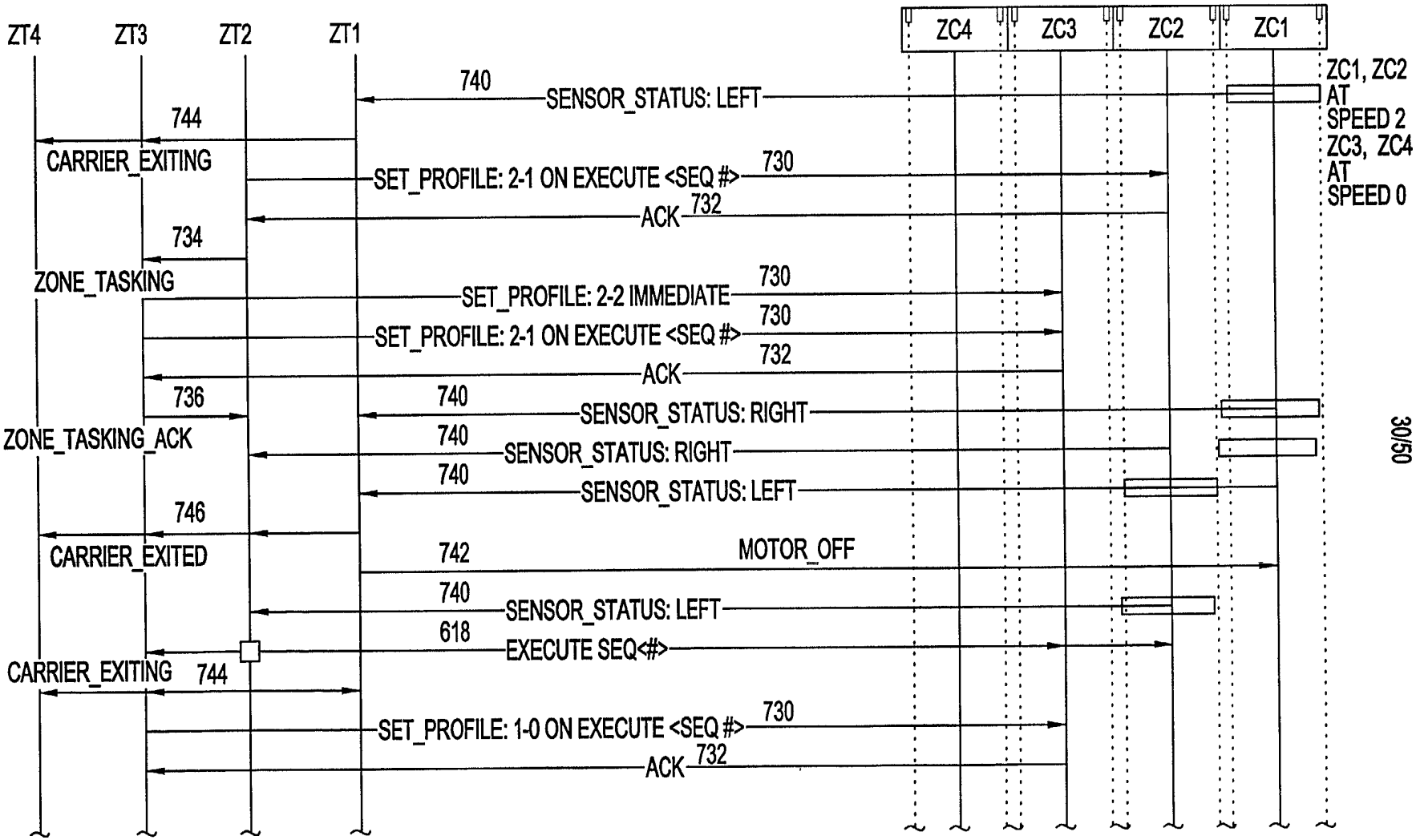

CONTINUED FROM FIG. 21B
742
MOTOR_OFF
740
SENSOR_STATUS: LEFT
618
EXECUTE <SEQ #>
744
EXECUTE <SEQ #>
CARRIER_EXITING
730
SET_PROFILE: 2-2 ON EXECUTE #
732
ACK
730
SET_PROFILE: 2-2 ON IMMEDIATE
730
SET_PROFILE: 2-2 ON EXECUTE #
732
ACK
740
SENSOR_STATUS: RIGHT
740
SENSOR_STATUS: RIGHT
ZONE_TASKING_2-2
734
ZONE_TASKING_ACK
736

FIG. 21C






CONTINUED TO FIG. 22B

FIG. 22A

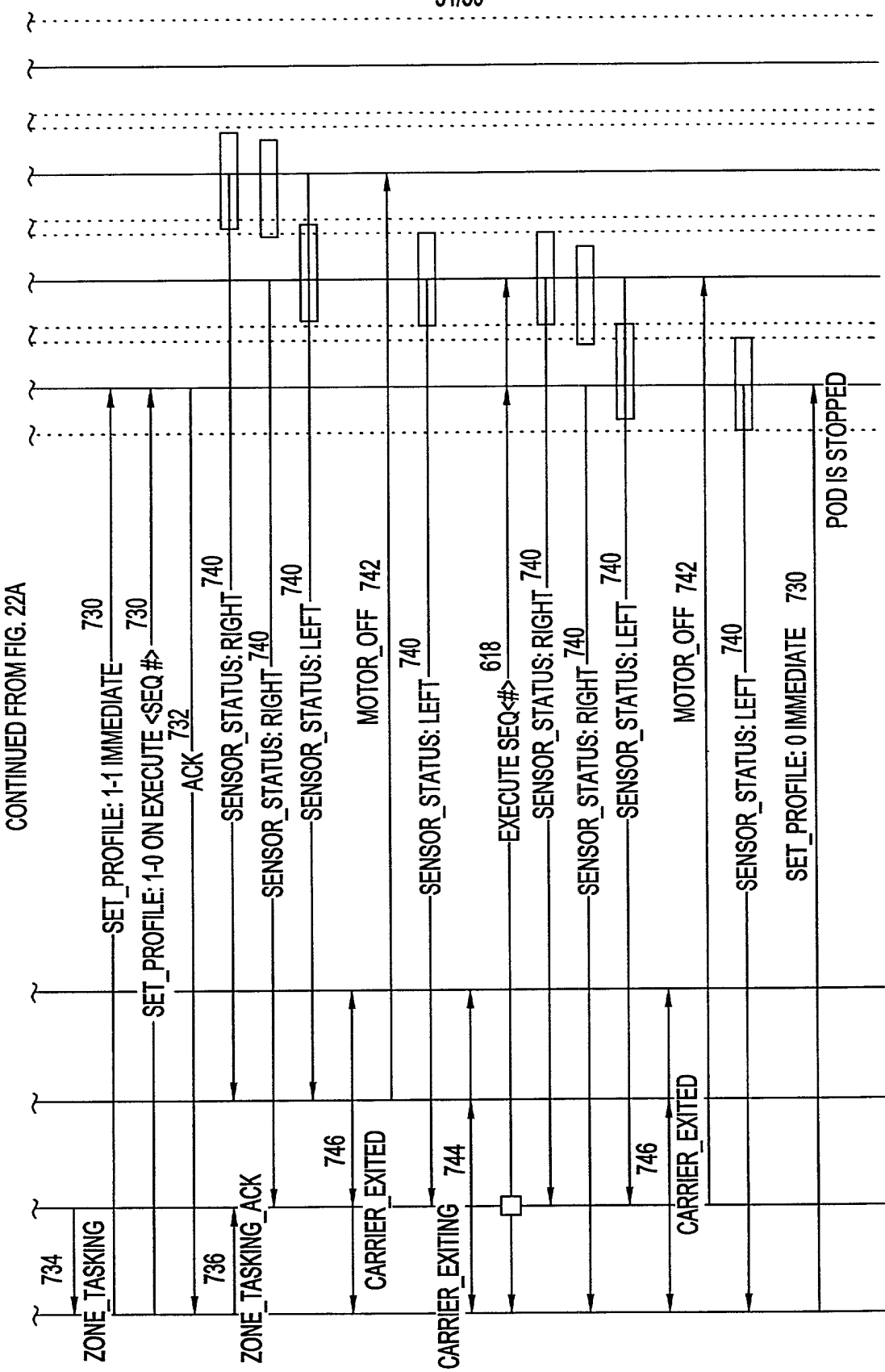
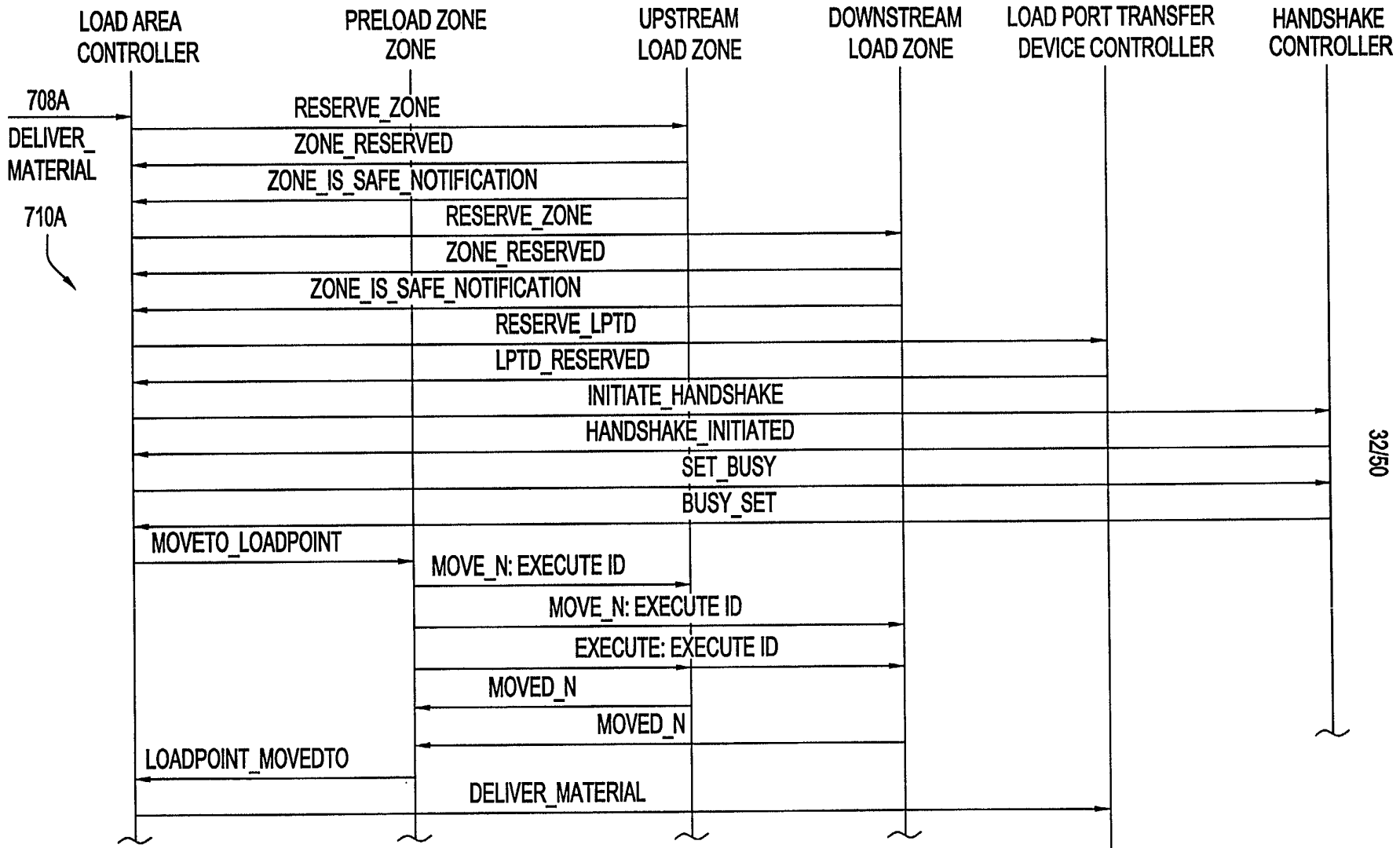

CONTINUED FROM FIG. 22A
ZONE_TASKING
734
SET_PROFILE: 1-1 IMMEDIATE
730
SET_PROFILE: 1-0 ON EXECUTE <SEQ #>
730
ACK
732
736
ZONE_TASKING_ACK
SENSOR_STATUS: RIGHT
740
SENSOR_STATUS: RIGHT
740
SENSOR_STATUS: LEFT
740
746
CARRIER_EXITED
MOTOR_OFF
742
SENSOR_STATUS: LEFT
740
CARRIER_EXITING
744
EXECUTE SEQ<#>
618
SENSOR_STATUS: RIGHT
740
SENSOR_STATUS: RIGHT
740
SENSOR_STATUS: LEFT
740
746
CARRIER_EXITED
MOTOR_OFF
742
SENSOR_STATUS: LEFT
740
SET_PROFILE: 0 IMMEDIATE
730
POD IS STOPPED

FIG. 22B




CONTINUED TO FIG. 23B

FIG. 23A

CONTINUED FROM FIG. 23A

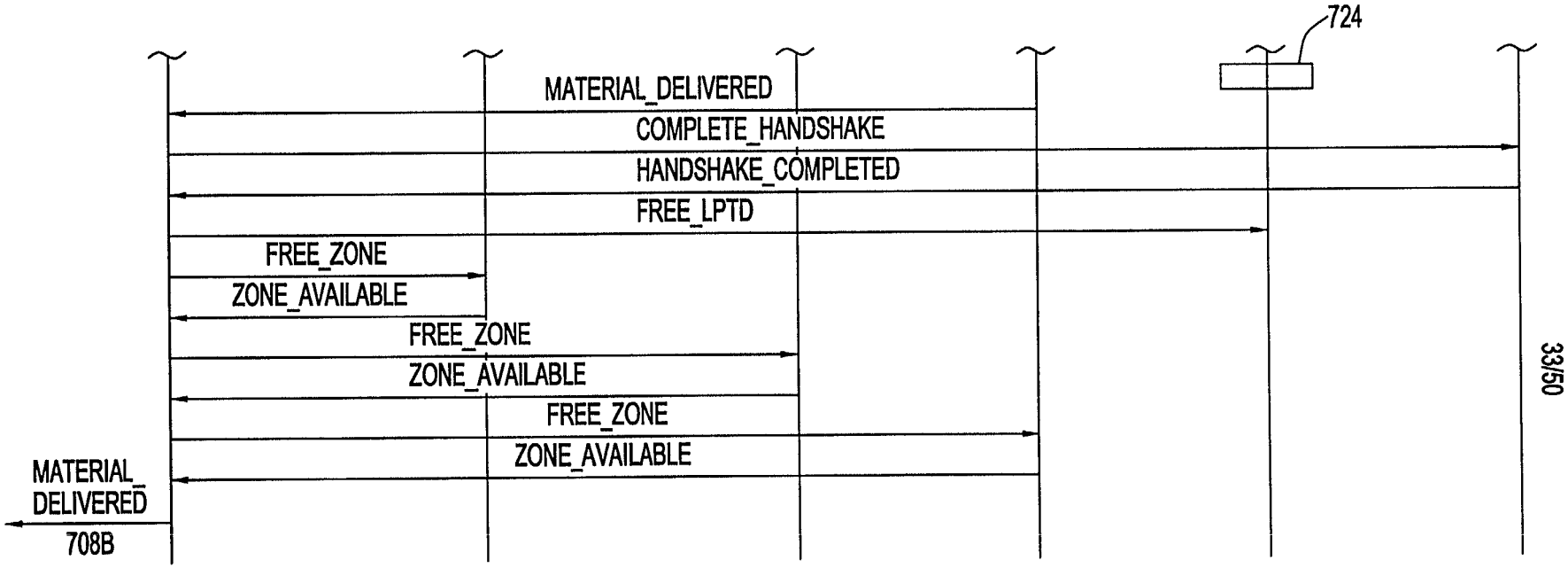



FIG. 23B

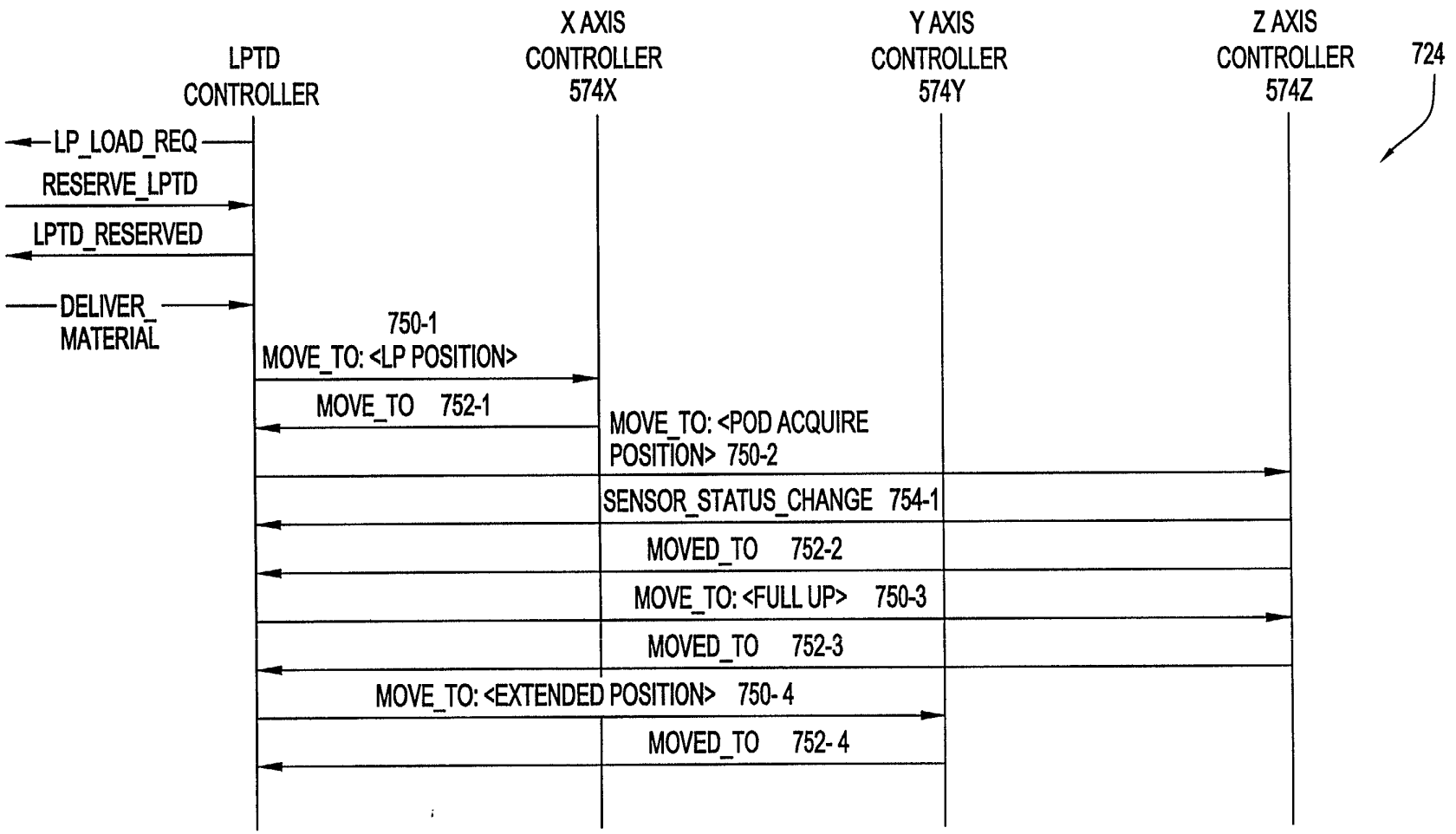

LPTD CONTROLLER
X AXIS CONTROLLER 574X
Y AXIS CONTROLLER 574Y
Z AXIS CONTROLLER 574Z
724
LP_LOAD_REQ
RESERVE_LPTD
LPTD_RESERVED
DELIVER_ MATERIAL
750-1
MOVE_TO: <LP POSITION>
MOVE_TO 752-1
MOVE_TO: <POD ACQUIRE POSITION> 750-2
SENSOR_STATUS_CHANGE 754-1
MOVED_TO 752-2
MOVE_TO: <FULL UP> 750-3
MOVED_TO 752-3
MOVE_TO: <EXTENDED POSITION> 750-4
MOVED_TO 752-4

FIG. 24A

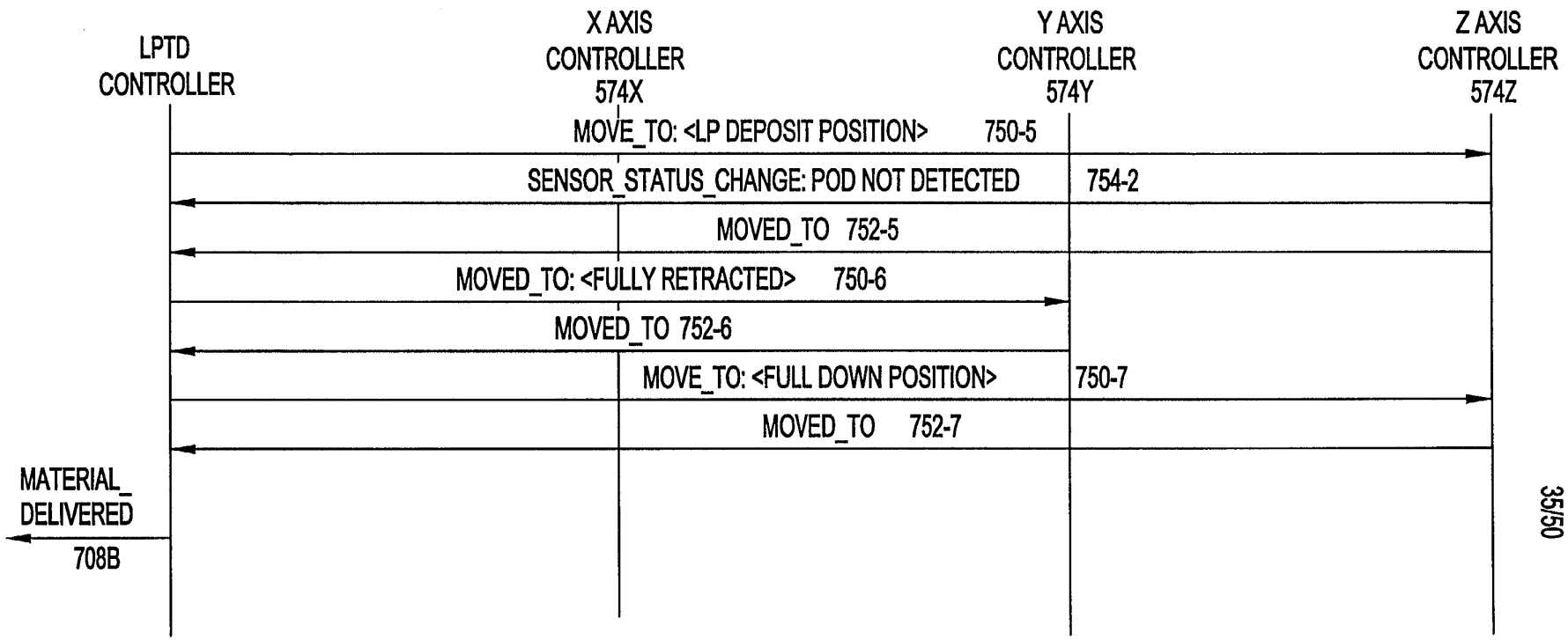



FIG. 24B

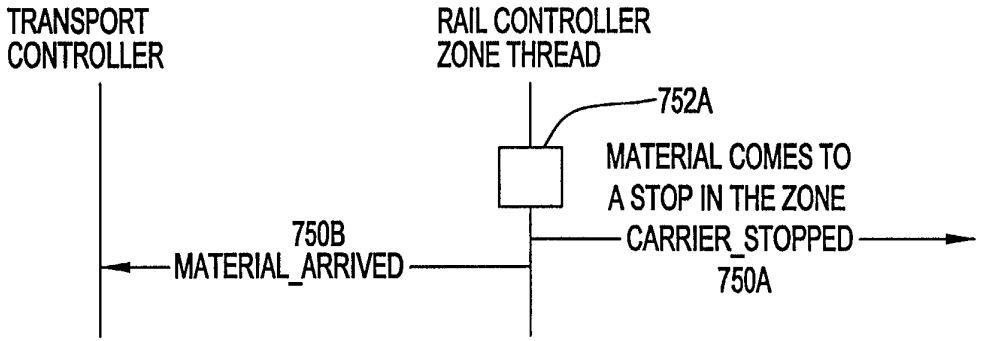



FIG. 25

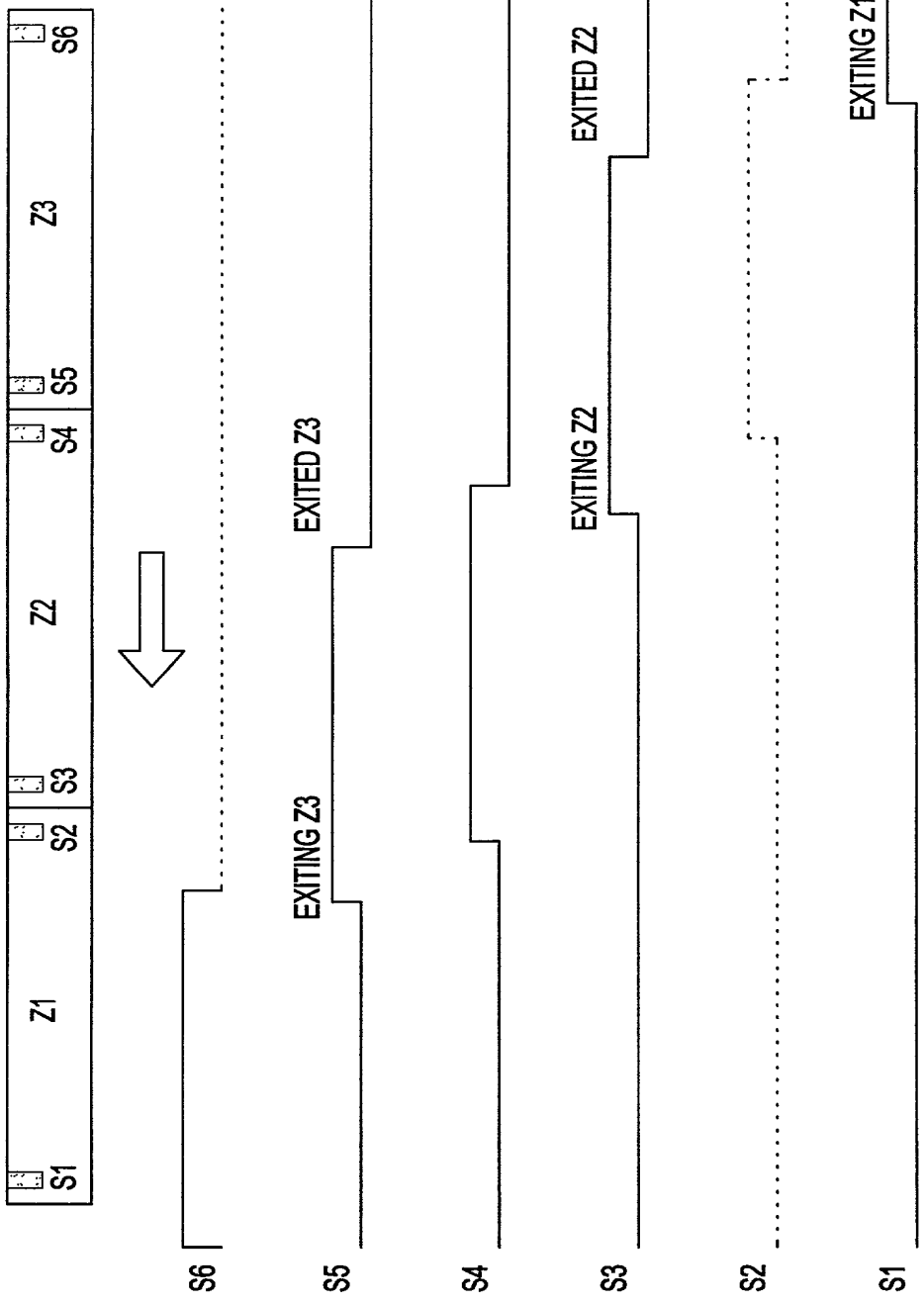

Z1
Z2
Z3
S1
S2
S3
S4
S5
S6
EXITING Z3
EXITED Z3
EXITING Z2
EXITED Z2
EXITING Z1
S6
S5
S4
S3
S2
S1

FIG. 26

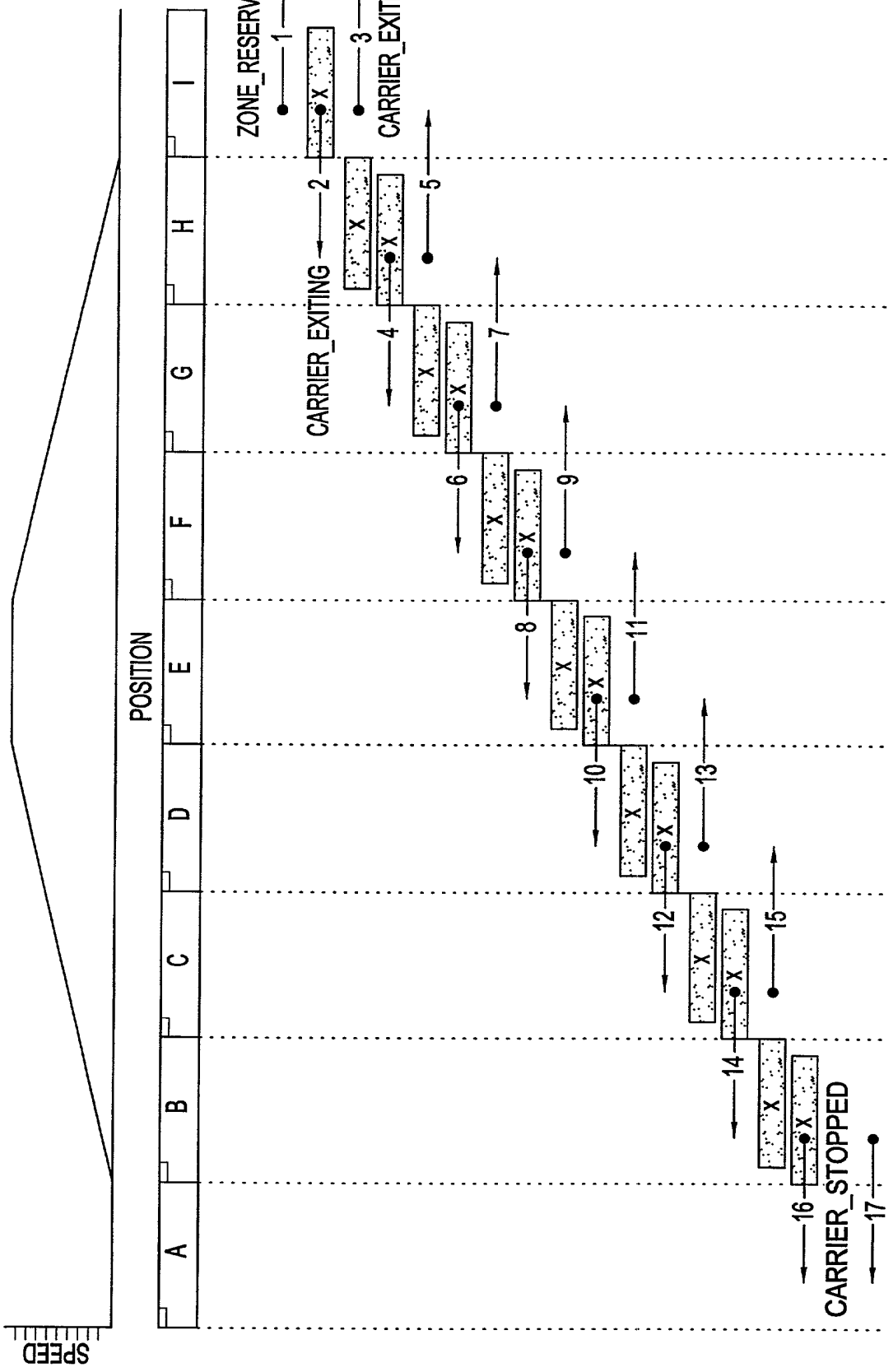

SPEED
POSITION
A
B
C
D
E
F
G
H
I
ZONE_RESERVED
CARRIER_EXITING
CARRIER_EXITED
CARRIER_STOPPED
ZONE_AVAILABLE
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
X

FIG. 27

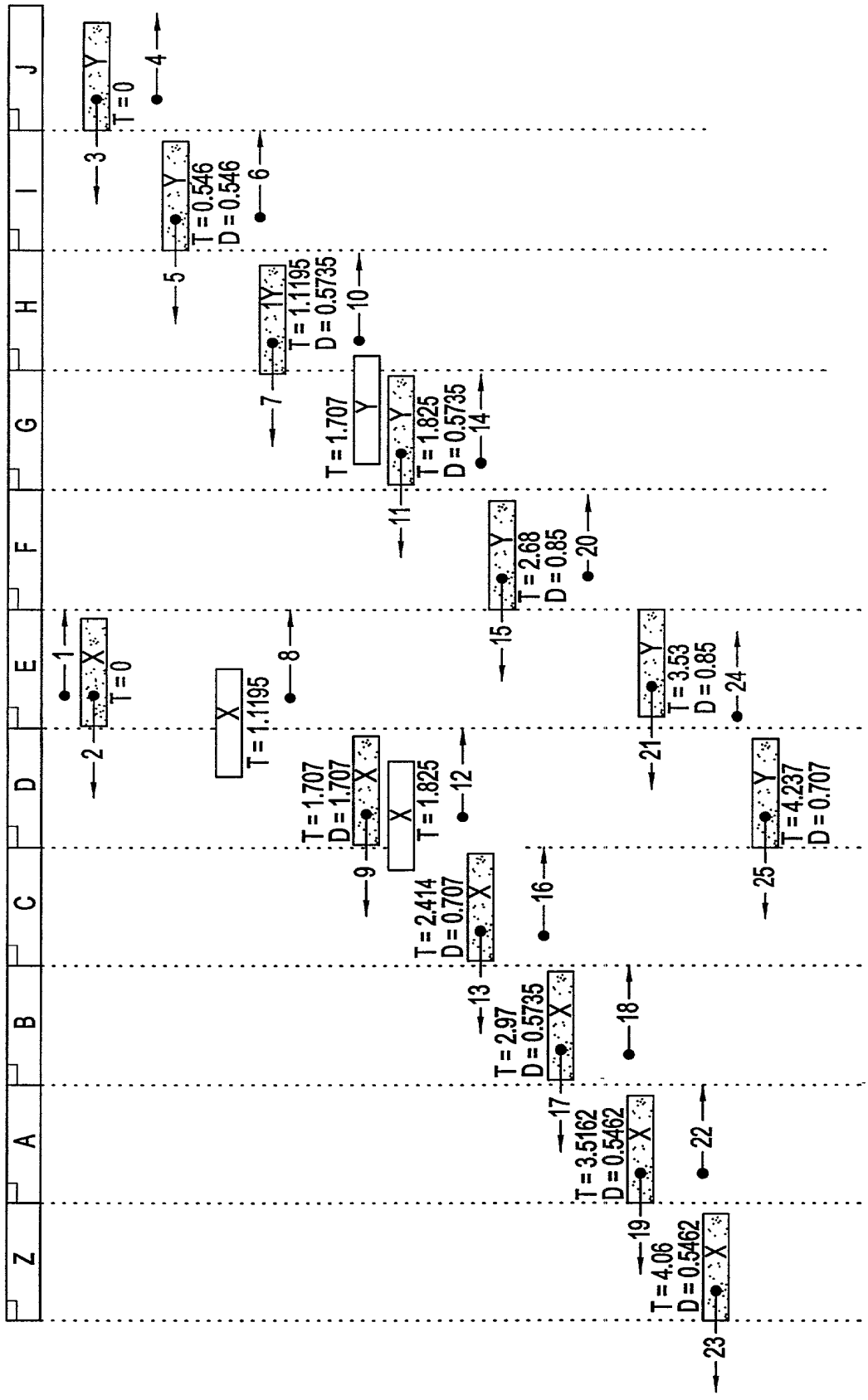

Z
A
B
C
D
E
F
G
H
I
J
1
2
T = 0
3
T = 0
4
5
T = 0.546
D = 0.546
6
7
T = 1.1195
D = 0.5735
8
T = 1.1195
9
T = 1.707
D = 1.707
10
T = 1.707
11
T = 1.825
D = 0.5735
12
T = 1.825
13
T = 2.414
D = 0.707
14
15
T = 2.68
D = 0.85
16
17
T = 2.97
D = 0.5735
18
19
T = 3.5162
D = 0.5462
20
21
T = 3.53
D = 0.85
22
23
T = 4.06
D = 0.5462
24
25
T = 4.237
D = 0.707

FIG. 28

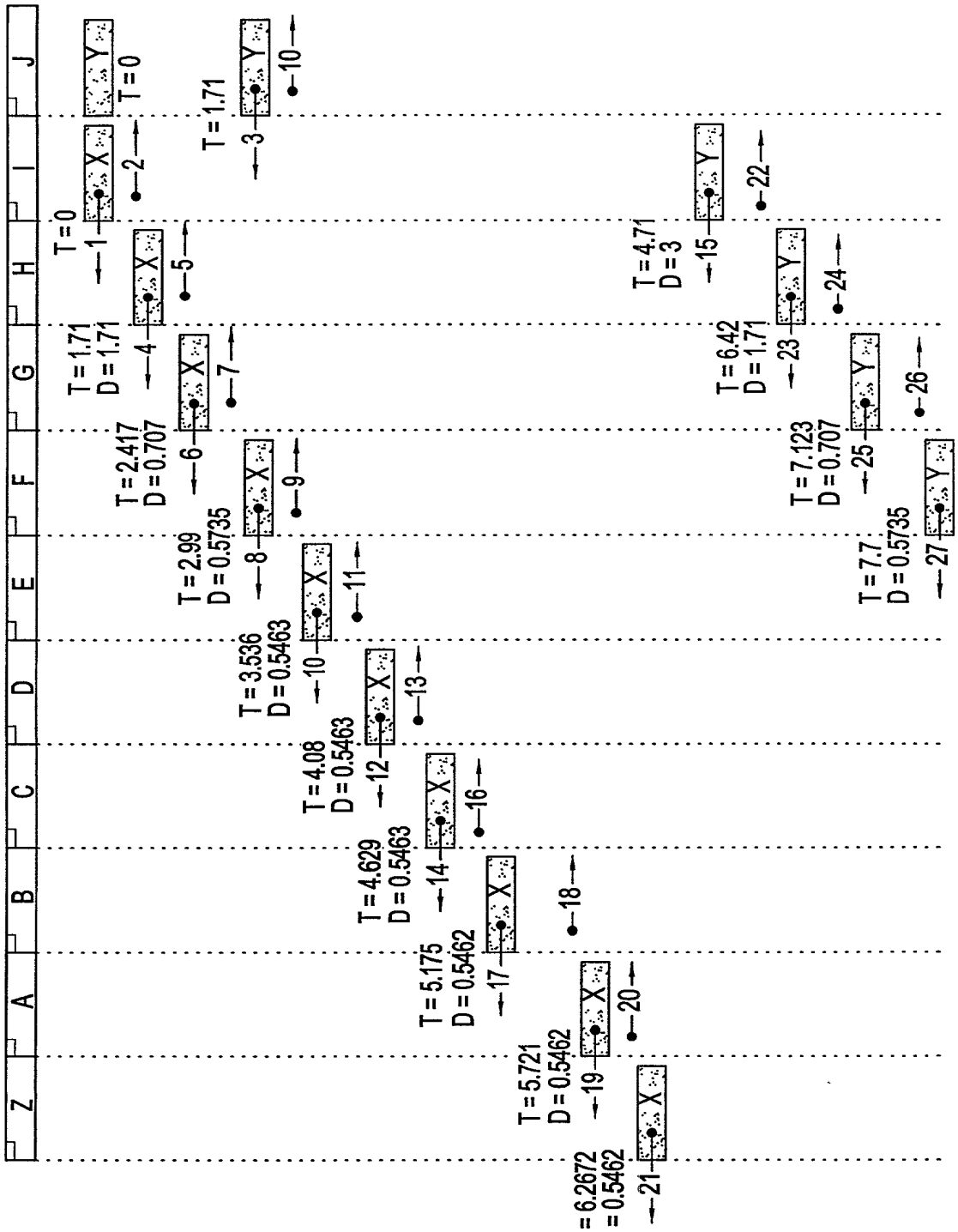

Z
A
B
C
D
E
F
G
H
I
J
T = 0
T = 1.71
D = 1.71
T = 2.417
D = 0.707
T = 2.99
D = 0.5735
T = 3.536
D = 0.5463
T = 4.08
D = 0.5463
T = 4.629
D = 0.5463
T = 5.175
D = 0.5462
T = 5.721
D = 0.5462
T = 6.2672
D = 0.5462
T = 1.71
T = 0
T = 4.71
D = 3
T = 6.42
D = 1.71
T = 7.123
D = 0.707
T = 7.7
D = 0.5735
X
Y
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27

FIG. 29

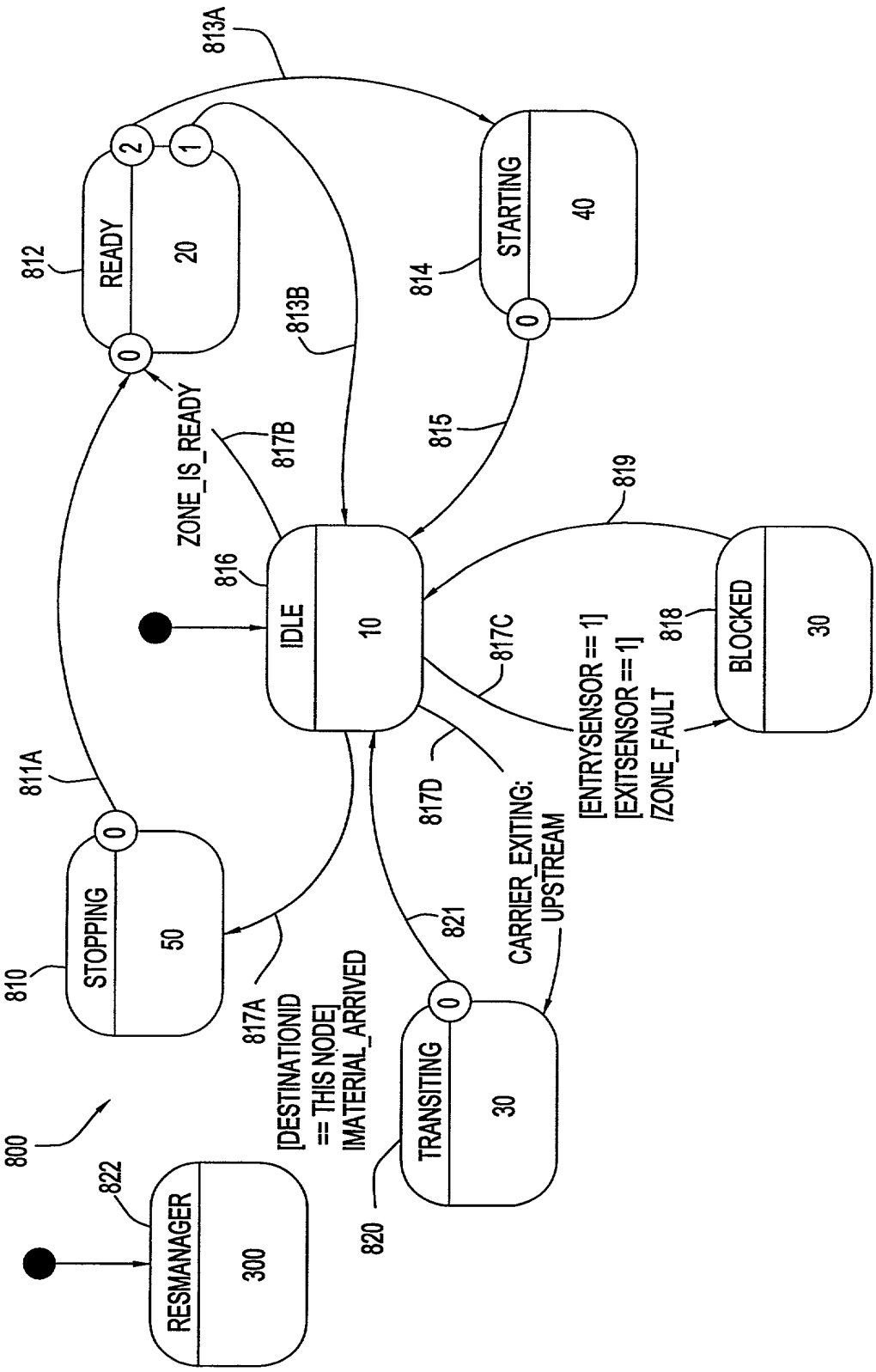

800
822
RESMANAGER
300
820
TRANSITING
30
821
CARRIER_EXITING:
UPSTREAM
817A
[DESTINATIONID
== THIS NODE]
IMATERIAL_ARRIVED
810
STOPPING
50
811A
812
READY
20
813A
813B
814
STARTING
40
815
816
IDLE
10
817B
ZONE_IS_READY
817C
817D
[ENTRYSENSOR == 1]
[EXITSENSOR == 1]
/ZONE_FAULT
818
BLOCKED
30
819

FIG. 30

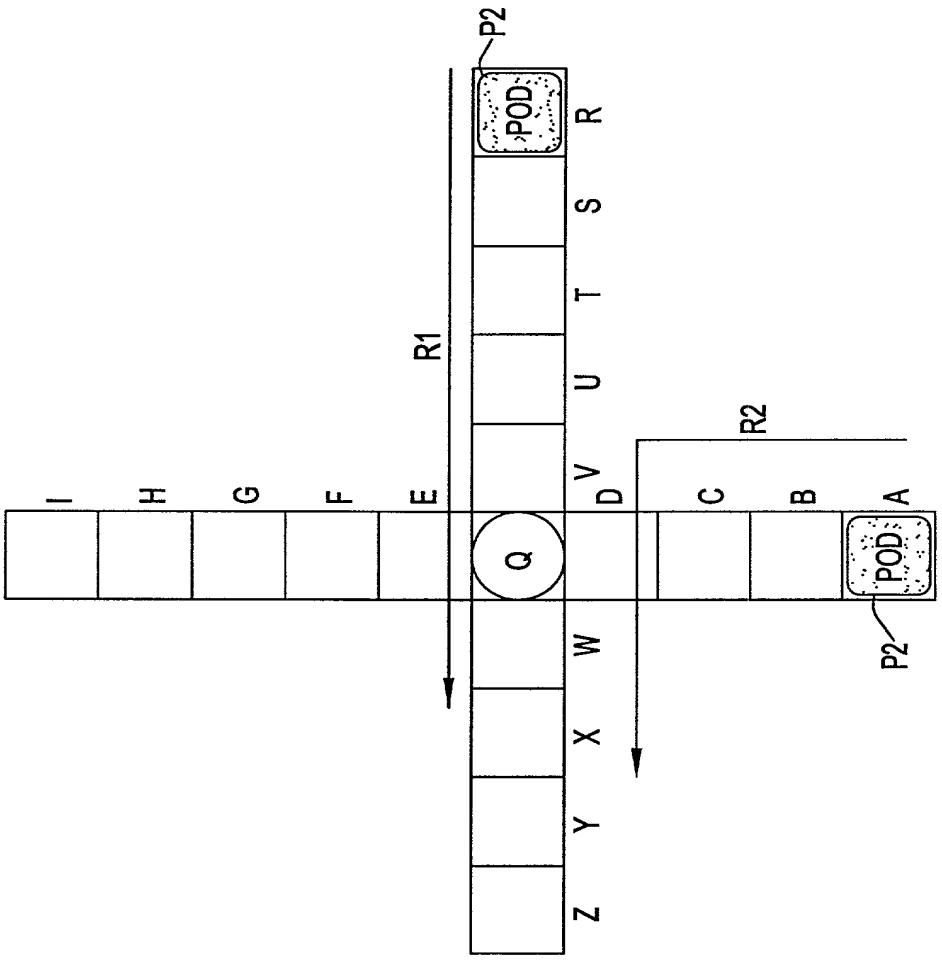
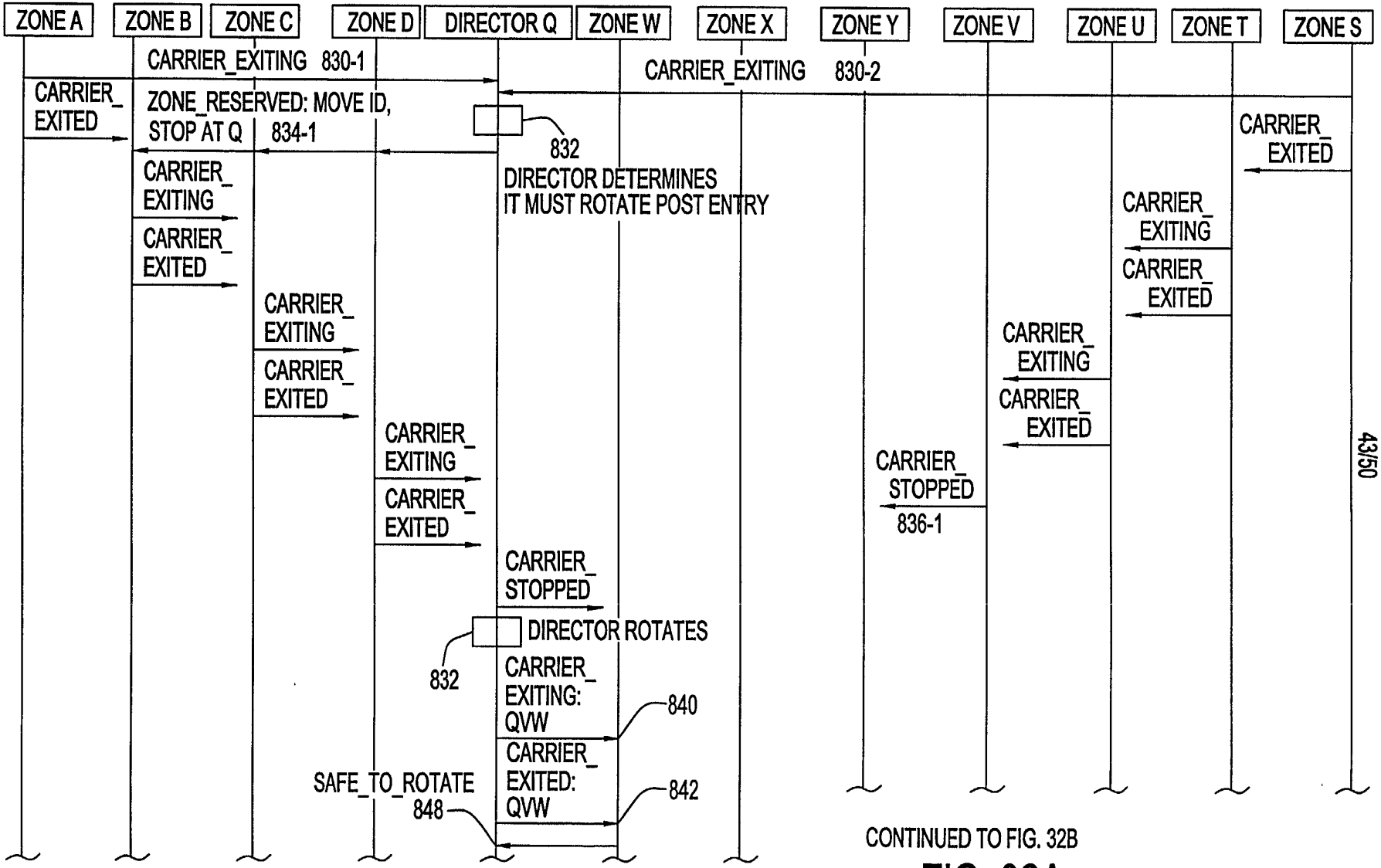



FIG. 31




CONTINUED TO FIG. 32B

FIG. 32A

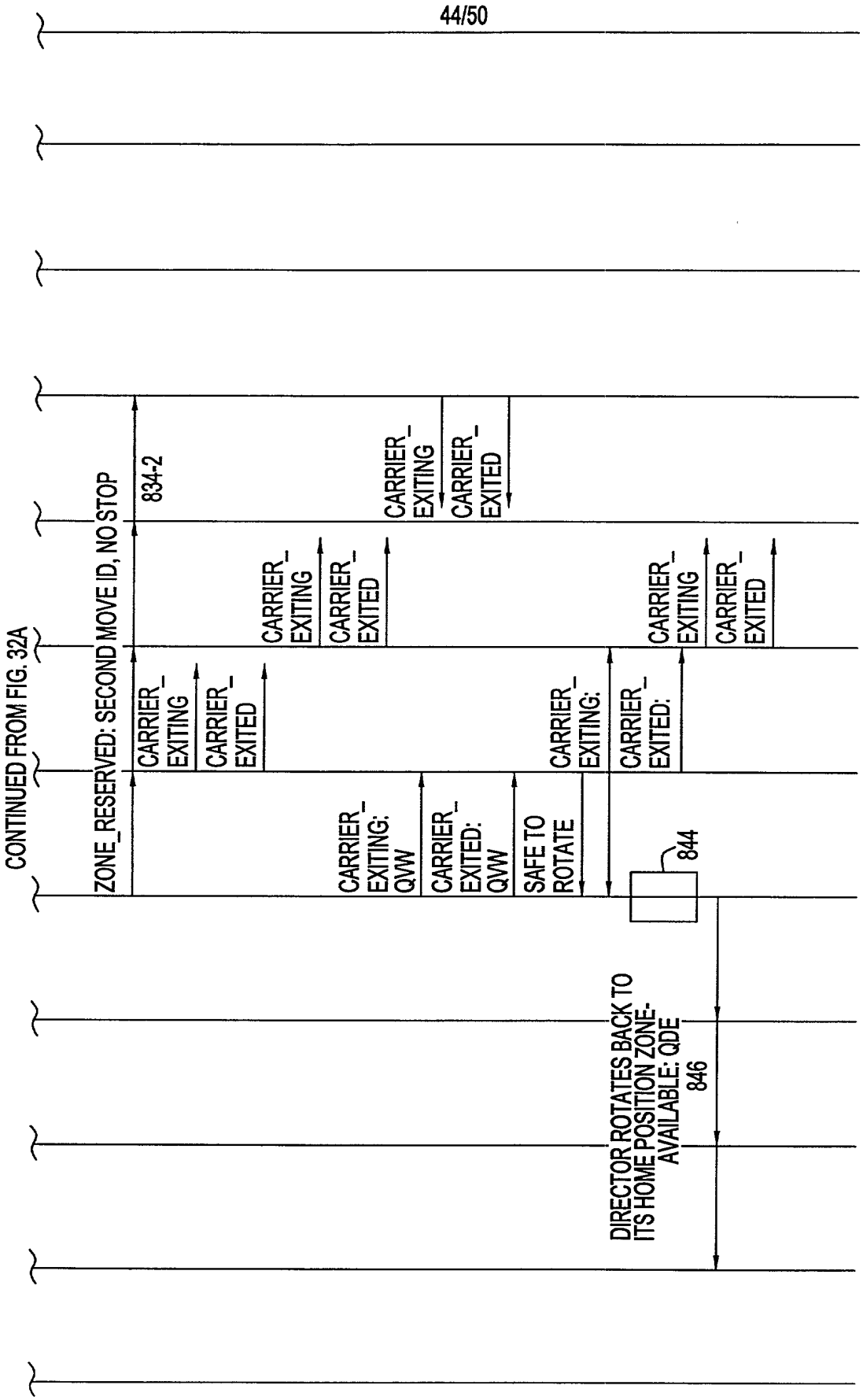

CONTINUED FROM FIG. 32A
ZONE_RESERVED: SECOND MOVE ID, NO STOP
834-2
CARRIER_ EXITING
CARRIER_ EXITED
CARRIER_ EXITING
CARRIER_ EXITED
CARRIER_ EXITING
CARRIER_ EXITED
CARRIER_ EXITING
CARRIER_ EXITED
CARRIER_ EXITING: QVW
CARRIER_ EXITED: QVW
SAFE TO ROTATE
CARRIER_ EXITING:
CARRIER_ EXITED:
844
DIRECTOR ROTATES BACK TO ITS HOME POSITION ZONE-AVAILABLE: QDE
846

FIG. 32B

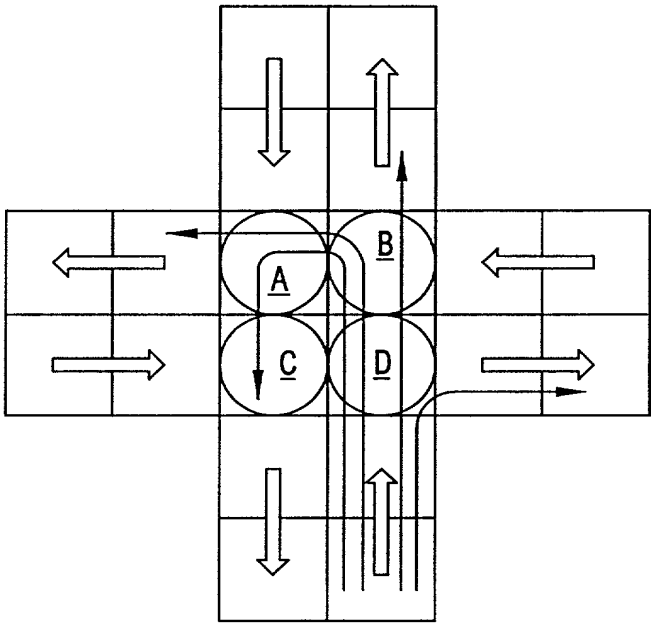



FIG. 33A

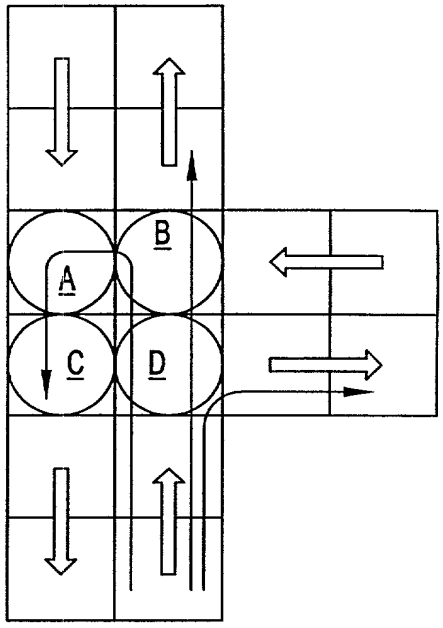



FIG. 33B

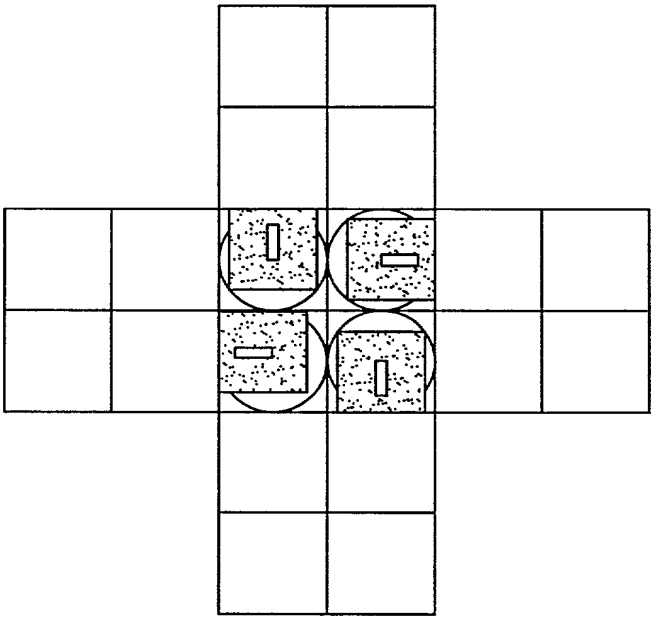


FIG. 33C

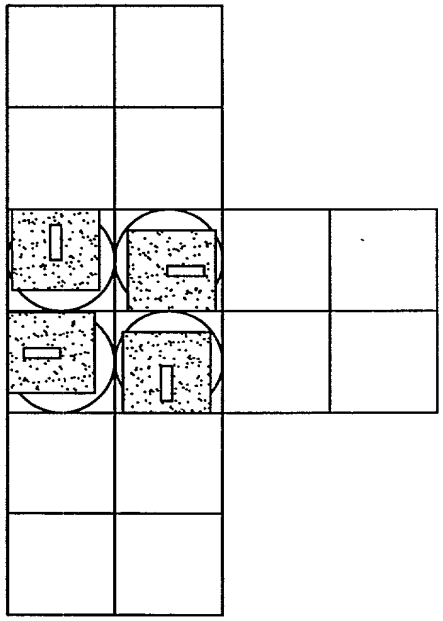


FIG. 33D

ROUTE DISCOVERY EXAMPLE:
PHYSICAL ZONE LAYOUT

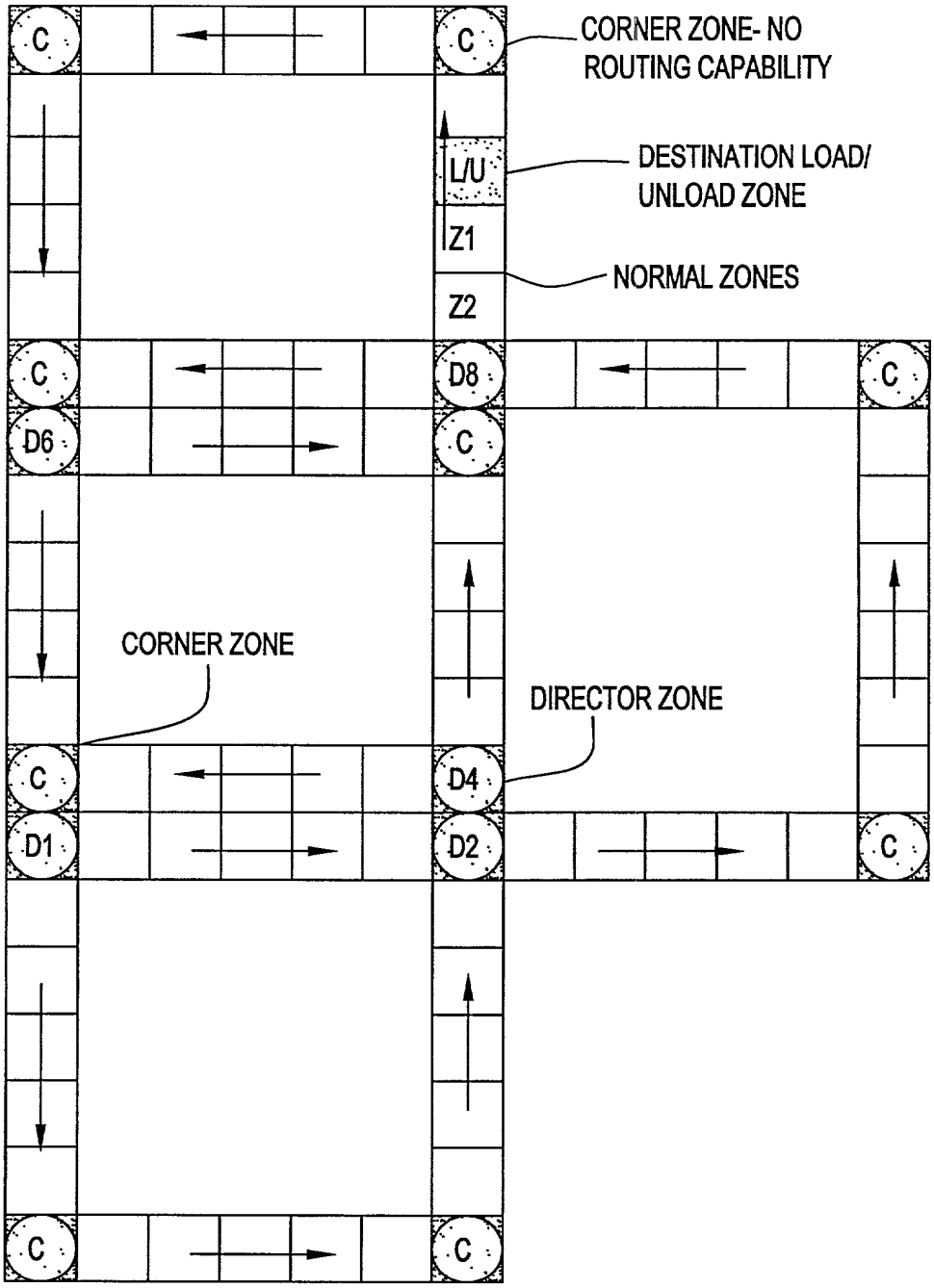



FIG. 34

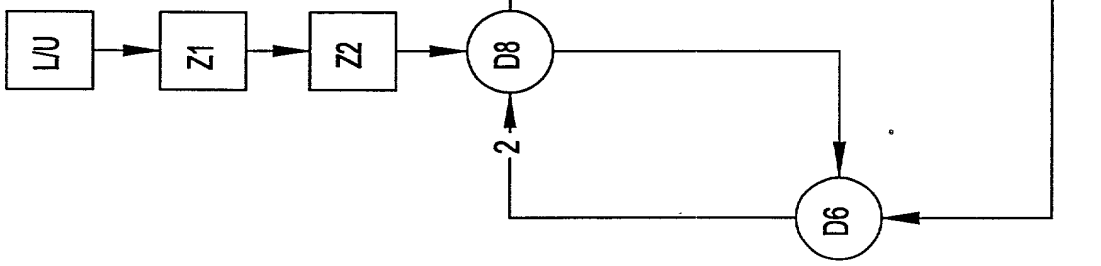

ROUTE DISCOVERY EXAMPLE:
UPSTREAM ZONE CONNECTIVITY
L/U
Z1
Z2
D8
D2
D4
D6
D1
2
2

FIG. 35

ROUTE DISCOVERY EXAMPLE:
PHYSICAL ZONE LAYOUT

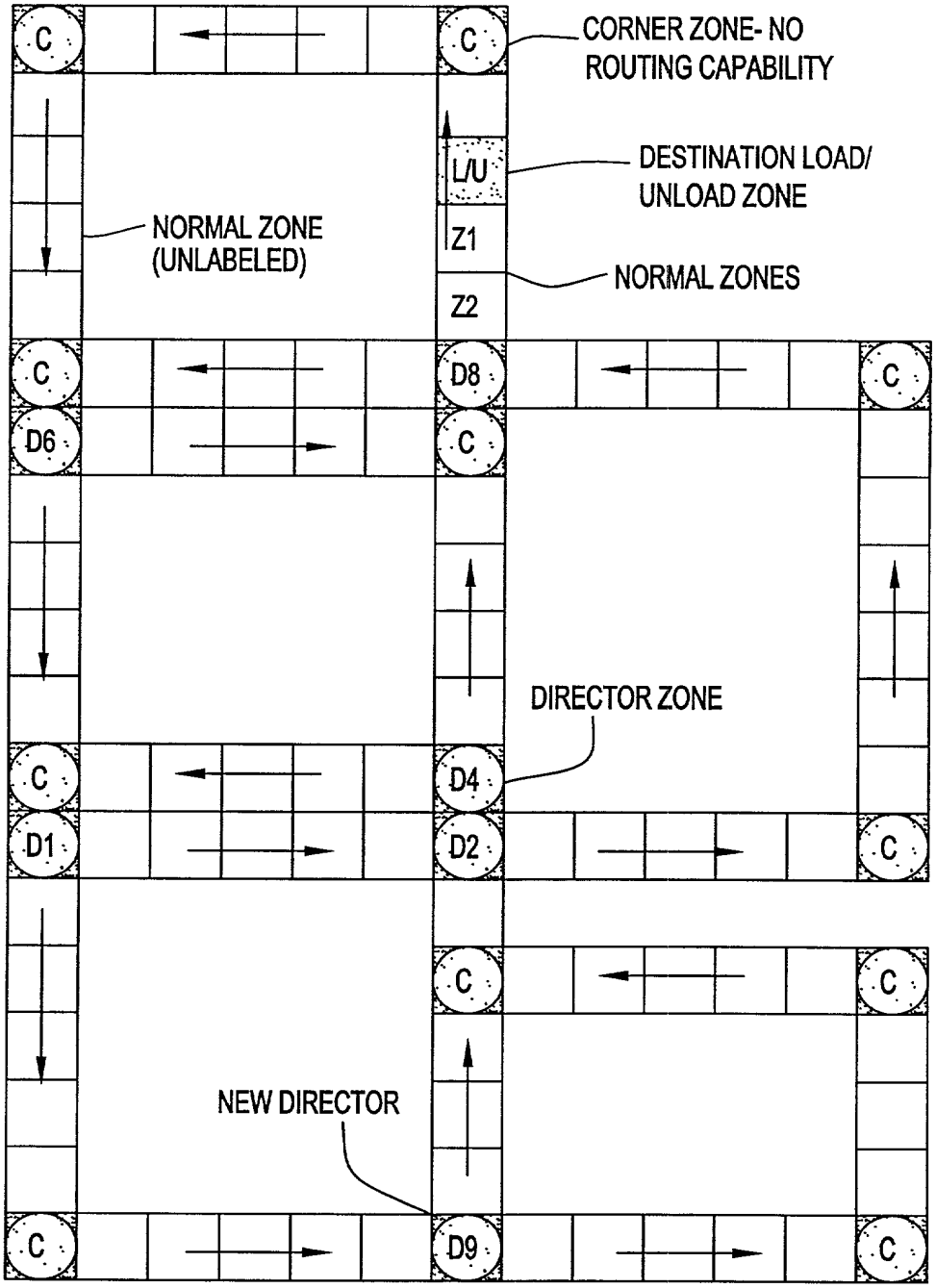



FIG. 36

FAILED NODE:
EXAMPLE LAYOUT

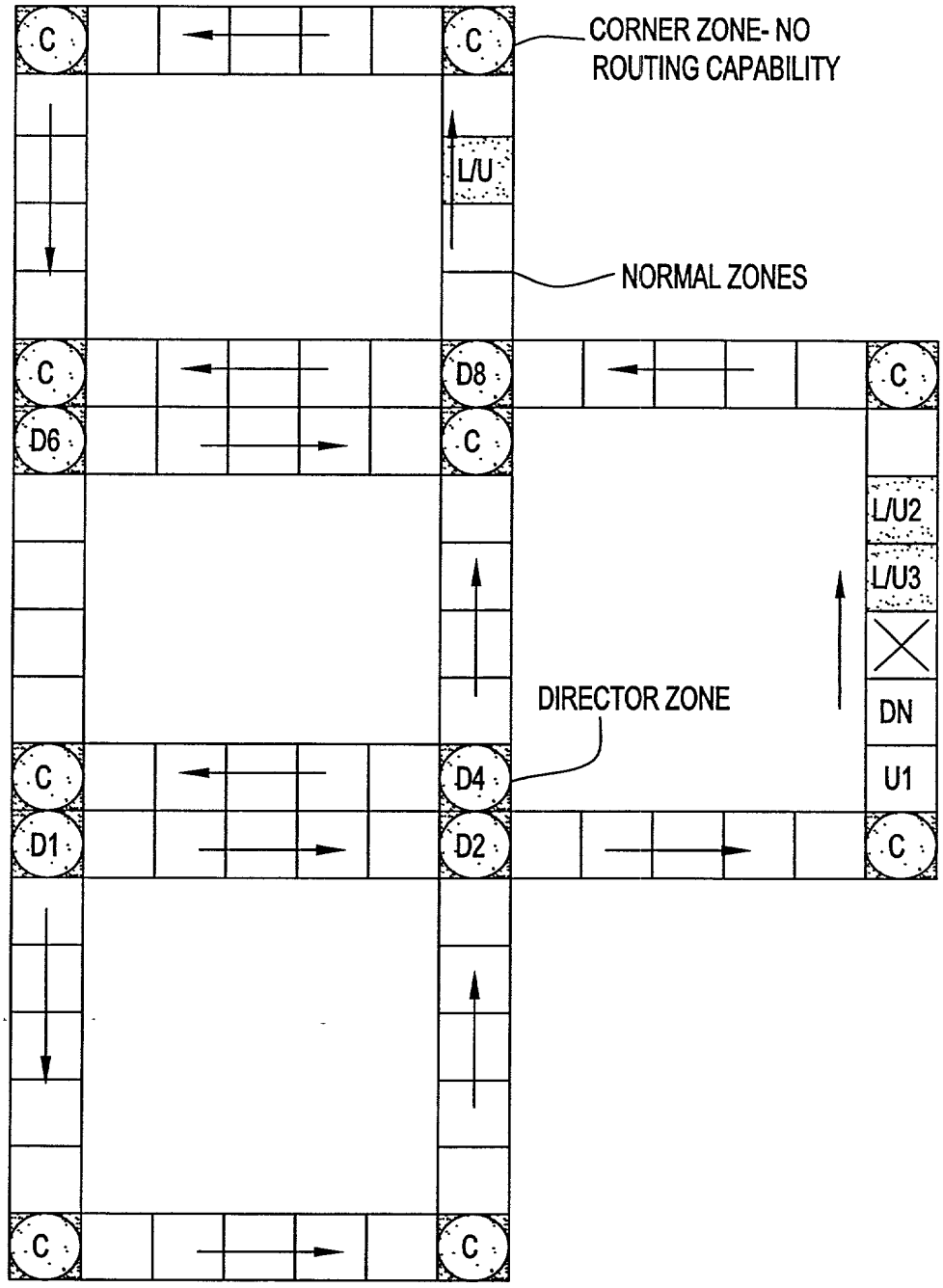



FIG. 37

FAILED DIRECTOR:
EXAMPLE LAYOUT:

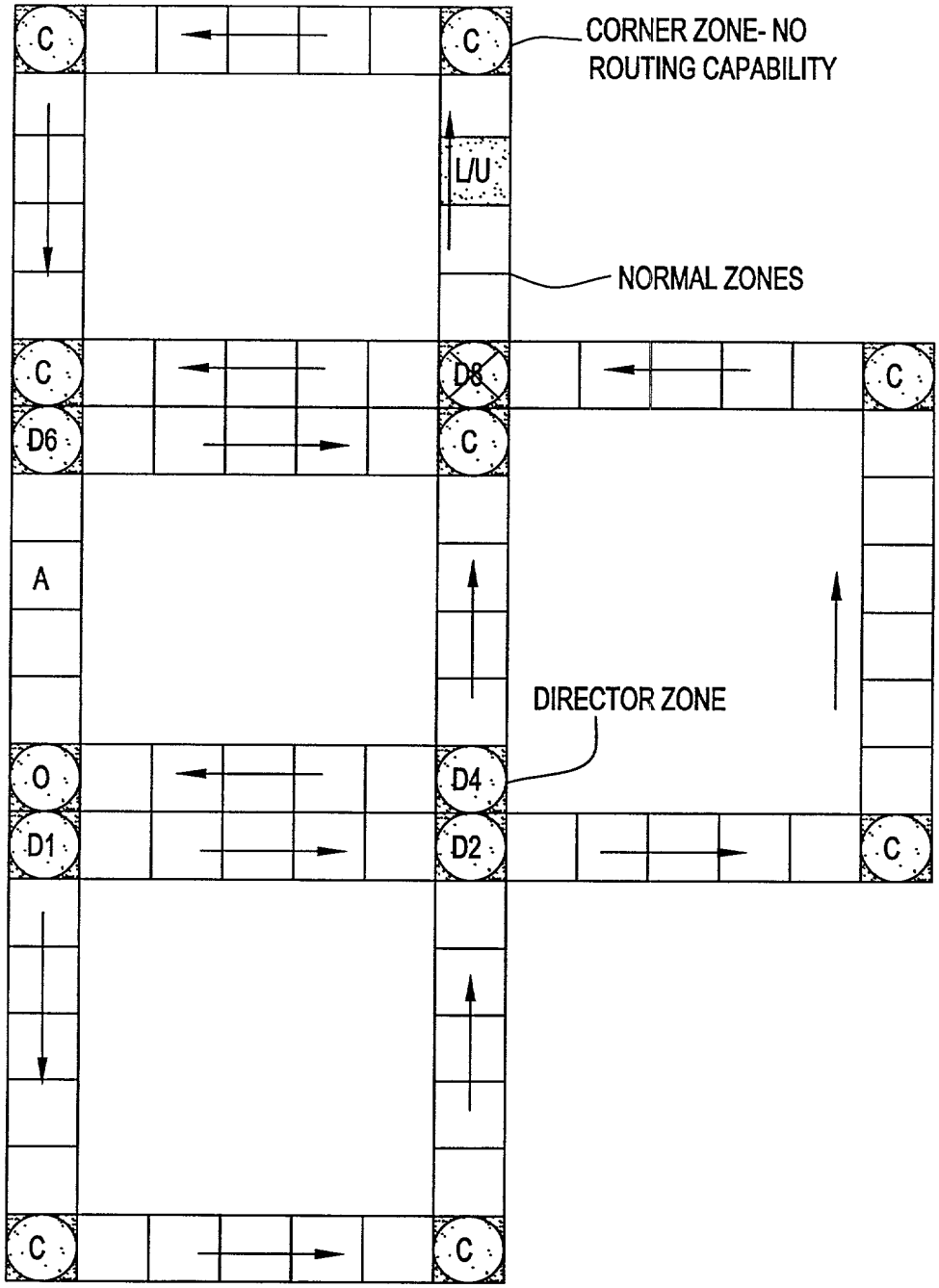



FIG. 38